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EJECTION SEAT TESTS CONDUCTED ON THE 10,000 FOOT AERODYNAMIC RESEARCH TRACK AT EDWARDS AIR FORCE BASE

C. K. HODELL
A. H. ROSNER

AIRCRAFT LABORATORY

NOVEMBER 1957

WRIGHT AIR DEVELOPMENT CENTER

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NOTICES

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November 1957

Project Nr 1362

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

FOREWORD

This report was prepared by the Special Projects Branch, Aircraft Laboratory, Directorate of Laboratories, Wright Air Development Center. The test program was initiated as part of the continuous research and development program identified by Project Nr 1362, "Escape From High Speed Aircraft," and Task Nr 13340 (formerly R 453-312). The tests were conducted on the 10,000 foot Free Air Test Facility Track, Edwards Air Force Base, under the supervision of the Escape Unit of the Special Projects Branch. Cooperating in the test was Northrop Aircraft, Incorporated, under research and development Contract Nr AF 33(038)-3096.

The following persons participated in all or part of these tests:

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FOREWORD - (Continued)

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ABSTRACT

Ejection seat tests were conducted from rocket propelled test carriages on the 10,000 foot FATF (Free Air Test Facility) Aerodynamic Research Track, Edwards Air Force Base. Limit aircraft speed for emergency escape utilizing current ejection seat - catapult combinations was investigated. Ejection seat trajectory and acceleration data applicable to aircraft flying at or near sonic speed were secured. Discrepancy of data obtained "in-flight", theoretically, and from the Aerodynamic Track rocket carriage are discussed in this report (see "Conclusions").

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

G H Schwartz

for RANDALL D. KEATOR
Colonel, USAF
Chief, Aircraft Laboratory
Directorate of Laboratories

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INTRODUCTION

Live and dummy ejection seat tests conducted by the Aircraft Laboratory during the past two years have shown that present USAF ejection seat-catapult combinations provide adequate tail clearance for all current USAF operational jet aircraft up to the design or limit airspeed of these aircraft. Further, the resultant wind blast pressures, deceleration and rotational forces, and parachute opening shocks were considered to be of insufficient magnitude to cause pilot injury or disorientation.

Although theoretical calculations have predicted that present and proposed ejection seat-catapult combinations will provide tail clearance for escape from aircraft capable of flights in the transonic speed range, the stability characteristics and the dynamic and structural adequacy of an ejection seat-pilot configuration ejected into regions of incompressible flow and sonic shocks have not been reliably predicted to date. Therefore, present transonic ejection seat trajectory data can only be considered as incomplete until such investigations in the transonic speed range can be accomplished.

It is of course realized that the limit aircraft speed for emergency escape utilizing the ejection seat will be determined by physiological limitations rather than by limitations of the catapultic device or because of structural considerations. Since transonic speeds were unobtainable with available existing test aircraft, supplemental ejection seat tests were conducted from rocket propelled test carriages on the 10,000 foot Free Air Test Facility Track, Edwards Air Force Base.

The test program was designed to further investigate the limit airspeed for emergency escape from aircraft utilizing current ejection seat-catapult combinations; to secure seat trajectory, stability and acceleration data applicable to aircraft capable of flights in the transonic speed range; and to study the effect upon seat trajectory and stability by varying such test configuration parameters as the length of catapult stroke, the length of guided catapult stroke, the center of gravity of the dummy-seat combination, and the catapult seat attachment point.

Manuscript released by the author September 1950 for publication as a WADC Technical Report.

PURPOSE

The purpose of this report is as follows:

1. To report on the ejection seat tests conducted on 10,000 foot Aerodynamic Research Track at Edwards Air Force Base from 5 December 1949 to 23 December 1949 and from 24 April 1950 to 15 July 1950.

2. To analyze the resultant trajectories of the ejection seat and the acceleration forces imposed upon the dummy subject.

3. To evaluate this data with respect to future operational uses of the ejection seat.

GENERAL DESCRIPTION OF TEST

The complete testing device consisted of a rocket propelled test carriage arranged for operation on the 10,000 foot Aerodynamic Research Track at Edwards Air Force Base. General views of the test carriage mounted on the track are shown in Figure 1.

The cockpit mock-up was designed to simulate the forward cockpit opening of the XF-89 airplane with canopy removed. It was of sufficient size to accommodate a pilot's ejection seat with an anthropomorphic dummy, together with necessary recording instrumentation (see Figure 2). Construction of the mock-up was to minimum strength requirements for anticipated design velocities. Commercial type materials were used wherever possible to minimize the cost of expendable articles.

In operation the test carriage, prepared with the desired test configuration, was propelled by the rocket motors toward the seat ejection area. The carriage starting position and number of rockets were predetermined as a function of carriage velocity desired at time of ejection. Braking of the carriage after the seat was ejected was accomplished through the use of retard rockets.

The test carriage was provided with instrumentation to record test information desired relative to velocity, and forces and effects with respect to the ejected seat and dummy. The instrumentation consisted of a complete telemetering recording system which transmitted intelligence via a mobile transmitter to receiving and recording equipment at a fixed station and a carriage motion recording system from which carriage velocity was obtained.

TEST EQUIPMENT AND FACILITIES

TRACK INSTALLATION (See Figure 3)

NOTE: Track stations are measured from west to east designated in hundredths. Each station multiplied by 100 is the measured distance from the Western terminus of the track, Station 00.00.

It was originally intended to fire the rocket test carriage vehicle in a west to east direction with the water trough at the Eastern extremity acting as the braking or decelerating device. However the following factors prompted the selection of an east to west firing direction.

1. Water for the trough was not available at the inception of the test program.

2. The contractor (Northrop Aircraft, Incorporated) had considerable experience in the use of rocket motors to decelerate test carriages on another similar track.

3. Removal of the water trough, located in the last 1800 feet of the east end of the track, would be mandatory for any contemplated west to east operations to preclude damage by the test carriage in the event of retardation rocket malfunction.

In all tests ejection of the seat from the test carriage was initiated by mechanical means. The cocked striker arm of a spring loaded catapult sear actuator mechanism was tripped by an inclined plane (Figure 4) mounted between the rails of the track. Since the seat was to be ejected from a fixed station of the track for every test (47.00, "station of ejection") it was necessary before each test to move the inclined plane a calculated distance ahead of the intended station of ejection as the test configuration varied. The above distance was computed by considering the following parameters:

1. Test carriage velocity

2. Type of catapult used

The carriage starting point varied from 800 to 1850 feet ahead of the intended station of ejection (Station 47.00). In all tests, except Test Nr X, the seat was ejected within a range of ±50 feet of Station 47.00. There was no planned recovery of the ejection seat-dummy combination. The accelerator rocket burn-out occurred before Station 47.00 therefore the test carriage was actually coasting through the track test section. The decelerator rockets were fired at two positions along the track. The first position was at Station 36.00, and the other position occurred variously at Stations 6.00, 10.00 and 15.00 for different tests.

The catapult striker assembly (Figure 4) was bolted rigidly to the track approximately at Station 47.70. It was constructed of a structural steel channel rail with structural steel supporting angles at either end. The forward end of the strike rail was adjustable to insure proper contact with the catapult trigger.

The retard rocket striker (Figure 5) consisted of a formed structural steel arm projecting from either side of the left hand track rail. Microswitch blades on the two front shoes of the test carriage were wiped off by steel striker arms which closed the electrical circuit between the power supply contained in the test carriage and the rocket motor igniters.

TEST CARRIAGE

Northrop Aircraft, Incorporated developed, designed and fabricated five rocket propelled test carriages, three of which were destroyed during the course of the test program. Each test carriage consisted of a structural cockpit mock-up, an ejection seat-dummy-catapult test configuration, and a modified JB-2 rocket launching sled. The contractor furnished engineering and maintenance personnel who assembled, maintained, repaired, modified and operated the test vehicle; determined rocket motor requirements for attaining specified test velocities; handles, installed, and fired the rocket motors; performed maintenance and repairs on the Aerodynamic Track.

The full scale cockpit mock-up (Northrop Drawing Nr 534057) was of identical design for all test carriages and was constructed to aerodynamically and dimensionally simulate the forward cockpit opening of the XF-89 airplane with canopy removed. The cockpit area so represented included the fixed windshield and extended to a point immediately aft of the forward seat.

Pilot seat installations were made to accommodate USAF catapult Type M-1 and Navy NAMC catapult Type I.

CHASSIS

The test carriage chassis was fabricated from a modified JB-2 launching car (Northrop Part Nr 534064). It consisted basically of a center tube with magnesium alloy cross beams at either end. Slippers supported the carriage at four points. They were of a design previously proven by experience to be especially adaptable to this type of test vehicle (Northrop Aircraft Drawing Nr 530121). The slipper shape extended over the track rail head and was provided with lips to grip the rail head, preventing the carriage from becoming disengaged from the track. Sufficient clearance was provided with respect to the track to minimize sliding friction forces. The rear slippers were aluminum castings, while those on the front were of a welded steel design. Mounting of the slippers to the carriage was via a single free-floating pin, permitting angular rotation in the vertical plane and lateral play with respect to the carriage, allowing for slight irregularties or misalignment of the track.

For the higher speed runs an auxiliary rack was provided for installation on the rear of the carriage chassis for holding additional rockets.

ENCLOSURE

The enclosure attached to the top of the carriage chassis provided general protective housing for the test seat, dummy, and instrumentation equipment. The enclosure aerodynamically and dimensionally simulated the forward cockpit opening of the XF-89 airplane from a point forward of the fixed windshield to a point immediately aft of the forward seat. The seat bulkhead and seat tracks are similar in construction to those used in the XF-89. Mountings for the electrical equipment carried within the enclosure were provided in the area aft of the seat bulkhead. A hinged door was provided in the rear for access to this compartment (Figure 6).

ROCKET PROPULSION

The propulsion for the test carriage was provided by the installation of one to five rocket motors of the following type (see Table I):

1. JATO 2.2KS11000E1, 10-3/8 inch rocket motor manufactured by Aerojet Engineering Corporation of Azusa, California.

2. Monsanto T-10E1, 10 inch rocket motor manufactured by Dayton Powder Works, Dayton, Ohio.

TABLE 1

ROCKET CHARACTERISTICS

Rocket Unit	Impulse	Thrust	Duration	Chamber Pressure	Specific Impulse	Impulse / Weight	Propellant Weight	Total Weight	Ideal Velocity
	Lbs-Sec	Lbs	Sec	PSI	Sec	Sec	Lbs	Lbs	MPH
5" HVAR (Navy)	5250	5980	0.88	1800	219	60	24	88	886
Monsanto 2CS10000-T10E1	20000	7900	2.53	547	167	81.5	120	246	1300
Aerojet 2.2KS-11000X102F1	24200	8840	2.73	995	169	90	143	270	1475

The specified carriage velocities were accomplished by varying the quantity and type of propellant rockets.

The rockets were installed in the cross beams of the chassis, being held in place by the clamping action of the beam halves. Welded steel adapters were provided to accommodate various sizes of rocket motors (see Figure 7).

The rockets were remotely fired from an operations truck stationed away from the track (see Figure 8). When the fire control switch in the operations truck was closed the rockets were fired. A quick disconnecting firing line was arranged to permit power transmittal from the track line to the carriage. The firing line was provided with a steel pull cable clamped to the track. Upon firing, the forward motion of the carriage pulled the disconnect plug via the steel cable. Suitably spaced electrical outlet boxes were arranged along the track to permit the firing of the rockets at the various carriage starting locations.

ROCKET RETARDATION

All test operations were based on a planned salvage of the mobile equipment through the use of retard rocket installation for carriage braking. The 5-inch HVAR and Aerojet rockets were used as decelerators (see Table 1). Installation of the retard rockets in the forward cross beams was similar to the propeller rocket installation. The quantity and type of rockets used was dependent upon test requirements.

Firing of the retard rockets was accomplished by means of a switch attached to the forward right hand slipper. The switch assembly, Figure 5, consisted of a steel holder that fitted over and was bolted to the slipper. On either side of the holder was a steel box containing a micro-switch. The switch was actuated by contact with a striker located at a predetermined position on the track. This closed the electrical firing circuit, Figure 8, to the rockets, the power being supplied by batteries located in the aft compartment of the enclosure, Figure 9.

SEAT INSTALLATION

There were originally several different ejection seat-dummy-catapult test configurations included in the test program. A standard XF-89 pilot's ejection seat was used in all test configurations, but the catapult type, length of ejection rails, seat and dummy cg location, position of catapult attachment to seat, head rest flap provisions, and drag chute provisions varied with individual test. However, as the test program progessed, preliminary data reduction, and test carriage and rocket malfunctions indicated that the proposed test configurations should not be rigidly adhered to. As a result, the individual test configurations

varied only in catapult type and in the length of the ejection rails. Every ejection seat-dummy-catapult test configuration contained the following items:

1. The ejection seat (Figure 10) was a modified XF-89 pilot's ejection seat (Northrop Drawing Nr 534062). The seat was fixed in the lowest or ejection position with the adjusting mechanism and linkage inoperative. The hydraulic cylinder for seat adjustment was replaced with a dummy strut. All seat ejection controls, hydraulic system, controls for seat adjustment and locking mechanisms were deleted. These items were replaced with properly located ballast or dummy parts to maintain design seat cg location. The shoulder harness take-up inertia reel was replaced with a simulated attachment fitting for the harness and a weighted dummy part since the inertia reel is locked when the seat is in the ejection position.

2. The dummy was a 175 pound articulated anthropomorphic dummy, minus hands and feet, with a cloth head (Figure 11). For Test Nr 1, 5, 6 and 7 the dummy was fitted with a cast aluminum head containing a pressure pick-up, a modified P-1 helmet, and an A-13A oxygen mask (Figure 2).

3. One of the following catapult types:

   a. USAF Catapult, Aircraft Personnel, M-1, with 65-1/2 inch stroke.

   b. USN Catapult, Personnel Ejection, NAMC Type I, with 40 inch stroke.

4. Belt; Aircraft Safety, Type B-14, Drawing Nr 44G 5437.

5. Belt; Safety, Type B-15 (Shoulder Harness), Drawing Nr 44G 5443.

6. Kit; Emergency Sustenance, Artic, Seat Style, Type E-20, USAF Specification Nr 20101 (Mock-up).

7. Parachute Assembly; 28 foot diameter, 7 inch (back) Type XB-14 (Mock-up).

CATAPULT AND TRIPPING MECHANISMS

The tripping mechanism is a mechanical device for operating the sear lever on the catapult by a striker located on the track. I consists of a system of two spring loaded tripper assemblies, a trigger assembly and a sear tripper. The lower tripper assembly and trigger are housed in a welded steel case mounted on the left side of the adjustable chassis cross beam. The trigger is set in motion by contact with the striker assembly on the track. As the trigger rotates counterclockwise approximately 10^{o}, a compression spring is released in the lower tripper assembly. The spring applies tension on a cable which in turn releases a

compression spring in the upper tripper assembly. This spring is connected directly to the sear tripper which rotates the sear lever firing the catapult. This system is used for firing the USAF Type M-1 catapult and is shown schematically in Figure 12. The installation is shown in Figures 13 and 14.

The installation for the Navy NAMC catapult Type I is shown schematically in Figure 15 and pictorially in Figure 16.

Provisions were also made for mounting the USAF Type M-1 catapult to fire through the combined cg of the seat and dummy although time did not permit the running of this test. The seat was designed for the catapult to attach to the underside by means of special brackets. To provide clearance of the catapult with the track bed, triangular welded steel supports were designed to raise the enclosure approximately 10 inches above the chassis cross beams. The center tube was cut out to allow the catapult to pass through. The tripping mechanism was revised to eliminate the upper tripper assembly. A schematic diagram of the installation is shown in Figure 17.

INSTRUMENTATION

Carriage Motion Recording System. - Northrop Aircraft, Incorporated, provided instrumentation to describe the test carriage motion, presenting the data in the form of a space-time record from which carriage velocity was secured. The system consisted of a permanent magnet attached to one of the carriage slippers which, when in motion, introduces a signal to inductance type coils spaced at definite intervals along the track. The induced signal is in turn amplified and operates a signal light in a high speed photographic recording movie camera. The signal light is photographed in conjunction with a timing lamp actuated by a 1,000 cps oscillator. The resultant record provides an indication of the time required for the carriage to traverse the distance between the coils located along the track.

The mechanical and electrical arrangement of the space-time recording system is illustrated in Figure 18. The inductance coils were located at 50 foot intervals from the carriage starting area and extended beyon the seat ejection point. A small permanent holding magnet is attached to the right hand forward slipper of the carriage and has a clearance of approximately 1/4-inch from the top of the installed coils, Figure 19. The recording camera (Figure 20) is driven by a 1/3-horsepower ac motor through a gear train and springbelt drive. The structure on the front of the camera is a lamp hood.

Telemetering Equipment. - The Directorate of Flight and All-Weather Testing instrumentation truck contained a multi-channel, sub-carrier receiver and a Miller Model "J" oscillograph to record the angular, longitudinal, normal and transverse accelerations imposed on the dummy subject during the seat ejection. The chest cavity of the anthropomorphic dummy contained a subcarrier telemeter transmitter with three to four channels depending on test conditions.

Photographic Coverage. - Technical Photographic Services Section, provided the following photographic coverage of the tests:

1. Three fixed 16 mm Eastman High Speed, Type 3 cameras were mounted on a 15 foot elevation tower (Figure 21) to cover the initial stages of the seat ejection and to record catapult velocity. A pulse amplifier picked up 100 cps beats of a General Radio, Type 815C Precision Tuning Fork and piped them to a 1/4 watt argon lamp mounted in the cameras. These cameras, equipped with 35 and 63 mm leans, ran at a frame frequency of 1500-2000 frames per second.

2. Four fixed, split-frame, 35 mm, wide angle Fastex cameras were mounted on a 30 foot elevation tower (Figure 22) to record test carriage velocities and the trajectory of the ejection seat. A pulse amplifier and General Radio, Ty pe 815C, tuning fork established timing marks of 1/100 second on the high speed film. These cameras mounted 2 inch lens and ran at a frame frequency of 1200-1500 frames per second.

3. A ribbon frame camera was mounted on the 30 foot elevation tower to photograph the trajectory of the ejection seat. This camera ran at a frame frequency of 128 frames per second.

4. A 16 mm Bell and Howell Superspeed camera was mounted in the forward section of the test carriage to photograph the initial stages of the seat ejection and to record any structural defects that might occur in the seat, ejection rails, or catapult. This camera mounted a modified 17 mm lens. The data obtained from this camera proved to be of little value.

Base Photographic Branch, Edwards Air Force Base, provided the following photographic coverage of the tests:

1. A hand-held 35 mm Type A-7 Eyemo camera and a hand-held K-24 camera were spotted at advantageous positions along the track to photograph the seat trajectory.

2. An Akley 35 mm motion picture camera covered the entire run of the test carriage.

Before each test run, the test number was painted on the XF-89 mock-up to provide identification for motion picture records. A cross was painted on the side of the XF-89 mock-up to serve as base lines for photographic analysis of the films to determine the position of the seat with respect to the mock-up during the ejection. A grid was painted on the aft end of the windshield and on the cockpit sill to provide a base scale from which distances could be measured on the films.

TEST RECORDS AND REMARKS

A series of eight rocket propelled runs and two static tests was conducted. A record of seven rocket propelled tests is included in Appendix I.

Table 2 gives data on the rocket propelled vehicle tests and condition of each test. Table 3 gives rocket utilization data and test vehicle information.

STATIC TESTS (Figure 23)

Two static seat ejection tests were conducted from the test vehicle mounted on the track to assure proper performance of the seat and ejection rail installations (see Table 2). These tests were not instrumented but photographic coverage of the ejections was obtained. The maximum heights of the trajectories were 46.7 and 46.2 feet. The horizontal travel of the seats was 15 feet in both instances. The angle of ejection was 11^{o}.

EXPERIMENTAL FIRING RUN (Figures 24 and 25)

In Test Nr X the test vehicle retard rockets ignited prematurely and the seat ejection was delayed until the test vehicle had left the test section of the track. As a result, no photographic data was obtained on this test. It has been determined that high inertia forces on the retard rocket switch trip device was the direct cause for the premature rocket ignition. The delay in catapult actuation was accountable to the fact that the spring loaded catapult sear actuation mechanism, acting through a length of Bowden type casing, was unable to overcome the binding produced in the casing by the inertia forces, until after the test vehicle began to decelerate. The retard rocket switch trip and the catapult actuation mechanism were subsequently modified.

TEST NUMBER 1

In Test Nr 1 the seat was ejected at approximately the desired station of the test section of the track and photographic and instrumentation data were obtained. The seat stability was very good. The seat rotated approximately 30^{o} forward about the transverse axis at the maximum height of the trajectory. The seat then revolved approximately 120^{o} backward from the above position about the transverse axis and 90^{o} to the left about the horizontal axis, whereupon it hit the ground. The test vehicle left the track and was destroyed shortly after reaching the midpoint of the section. It was found that the high aerodynamic lift forces developed by the XF-89 mock-up had produced high frictional forces between the forward test vehicle cast aluminum slipper shoulder and the railhead. When the shoulders had war away, the test vehicle thereupon left the track. Steel test vehicle slippers with stellite inserts were fabricated for the succeeding tests.

TABLE

DATA ON ROCKET PROPELL

TEST NO.	DATE	AMBIENT TEMP. °F	EJECTION VELOCITY MPH	MACH NO.	EJEC WEIG LB.
STATIC #1	15 Dec. 1949				310
STATIC #2	16 Dec. 1949				310
X	21 Dec. 1949	50	(575) 465	0.607	324
1	5 May 1950	85	(575) 593	0.788	324
2	24 May 1950	83	(575) 578	0.768	324
3	1 June 1950	100	(650) 660	0.877	324
4	3 June 1950	94.5	(650)		32
5	13 June 1950	76	(650)		32
6	7 July 1950	97	(450) 470	0.624	32
7	13 July 1950	107.5	(650) unknown		324

NOTES: (1) Ejection angle 11° (2) Ejection velocity in parenthesis i
The second ejection velocity is th

TABLE 2

N ROCKET PROPELLED VEHICLE TESTS

N Y	MACH NO.	EJECTION WEIGHT LBS.	GUIDED STROKE INCHES	CATAPULT TYPE	REMARKS
		310	31.6	USAF M-1	Satisfactory Ejection
		310	31.6	USAF M-1	Satisfactory Ejection
	0.607	324	31.6	USAF M-1	Seat ejected beyond track test section; no data obtained.
	0.788	324	31.6	USAF M-1	Satisfactory test. Data was obtained although test carriage was destroyed.
	0.768	324	40.0	NAMC Type 1	Satisfactory test. Fully guided catapult stroke.
	0.877	324	40.0	NAMC Type 1	Satisfactory test. Fully guided catapult stroke.
		324	40.0	NAMC Type 1	Propulsion rockets exploded upon ignition and destroyed test carriage. No data
		324	31.6	USAF M-1	Test carriage disintegrated before entering track test section. No data obtained.
	0.624	324	31.6	USAF M-1	Test satisfactory although retard rockets ignited prematurely
		324	31.6	USAF M-1	Smoke of prematurely ignited retard rockets obscured test carriage. Data unsatisfactory

.ocity in parenthesis is target test velocity.
ejection velocity is the actual test velocity.

2

TABLE 3

ROCKET UTILIZATION AND TEST VEHI(

TEST NO.	DATE	AMBIENT TEMP.	TEST VEHICLE WEIGHT	STARTING POINT	CATAPULT TRIPPER	SEAT EJECT	RETARD ROCKET TRIPPER
		°F	LBS.	TRACK STATION	TRACK STATION	TRACK STATION	TRACK STATION
X	21 Dec. 1949	50	2300	55.00	48.20	29.00	6.00
1	5 May 1950	85	2749	57.00	49.40	48.00*	6.00
2	24 May 1950	83	2760	57.00	49.00	47.00	36.00 6.00
3	1 June 1950	100	3023	59.00	50.00	47.50	36.00 10.00
4	3 June 1950	94.5	3023	59.00	49.40		36.00 10.00
5	13 June 1950	76	2845	62.00	49.40		36.00 10.00
6	7 July 1950	97	2418	65.50	48.00	47.00	36.00 10.00
7	13 July 1950	107.5	2964	60.50	48.70	47.00	36.00 15.00

NOTES: Rocket abbreviations:

(1) HVAR = Naval Arsenal 5" HVAR
T10E1 = Monsanto 2CS10000-T10E1
2.2KS = Aerojet 2.2KS-11000X102F1

(2) Ejection velocity in parenthes
The second ejection velocity i

(3) * = "Approximate"

TABLE 3

TION AND TEST VEHICLE DATA

SEAT EJECT TRACK STATION	RETARD ROCKET TRIPPER TRACK STATION	ACCELER-ATION ROCKETS	DECELER-ATION ROCKETS	EJEC-TION VEL. MPH	REMARKS
29.00	6.00	(3) T10E1	(5) HVAR	(575) 465	Retard rockets ignited prematurely
48.00*	6.00	(4) T10E1	(2) HVAR (1) 2.2KS	(575) 593	Test satisfactory
47.00	36.00 6.00	(4) T10E1	(2) HVAR (1) 2.2KS	(575) 578	Test satisfactory
47.50	36.00 10.00	(5) T10E1	(2) HVAR (1) 2.2KS	(650) 660	Test satisfactory
	36.00 10.00	(5) T10E1	(2) HVAR (1) 2.2KS	(650)	Two T10E1 rockets exploded upon ignition.
	36.00 10.00	(4) 2.2KS	(2) HVAR (1) 2.2KS	(650)	Test carriage dis-integrated at Track Station 58.00
47.00	36.00 10.00	(3) 2.2KS	(3) HVAR	(450) 470	Retard rockets ignited prematurely.
47.00	36.00 15.00	(4) 2.2KS	(2) 2.2KS	(650) .600*	Retard rockets ignited prematurely

on velocity in parenthesis is target test velocity.
econd ejection velocity is the actual test velocity.

pproximate"

2

The test vehicle velocity versus track stations is given in Figure 26. The trajectory of the dummy relative to the vehicle is given in Figure 27. The trajectory of the cg with respect to the reference point (refer to individual test in Appendix I) is given in Figure 28.

By superimposing the outline of the XF-89 airplane on graphs such as Figure 27, and expanding the X-axis, it is possible to determine the clearance of the seat with respect to the tail of the airplane. These actual and theoretical clearances are plotted in Figure 29 for Tests 1, 2, 3 and 6.

The theoretical clearances were calculated mathematically by the "explicit method" outlined in AF Technical Report Nr 6350, dated March 1951. A sample calculation is given in Appendix II. Table 4 gives the actual and calculated vertical displacements for Runs 1, 2, 3 and 6.

TEST NUMBER 2

The results of this test, utilizing the Navy NAMC Type I fully guided catapult stroke are plotted in Figures 30, 31 and 32. The tail clearance is shown in Figure 29 and a summation of the test is given in Appendix I. This run was considered successful even though the drive motor of the recording oscillograph failed to rotate the drum. No oscillograph recordings were obtained. Photographic coverage was complete as shown by Figure 33.

TEST NUMBER 3

In Test Nr 3 the seat stability was good. The seat rotated approximately 20° forward about the transverse axis at the maximum height of the trajectory. The seat then continued to rotate forward about the transverse axis until it had reached a maximum angle of approximately 80° from the vertical. A restoring moment then caused the seat to rotate to the rearward about the transverse axis and at the instant of impact the seat was approximately 10° forward of the vertical. This test configuration again consisted of the Navy NAMC Type I catapult with the 40 inch length ejection rails which permitted a fully guided catapult stroke.

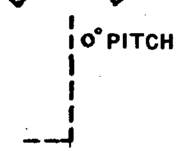
The results of this test are plotted in Figures 34, 35 and 36. The tail clearance is shown in Figure 29 and a summation of the test is given in Appendix I. Figure 37 is a film strip of Test Nr 3 showing the seat being ejected.

TEST NUMBER 4

This run was unsuccessful due to the explosion of propulsion rockets upon ignition. The test carriage was destroyed and of course no data was obtained. See Test Nr 4, Appendix I. Figure 38 shows the explosion and its damage.

TABLE 4

ACTUAL AND CALCULATED VERTICAL DISPLACEMENT AT FIN OF AIRPLANE

TEST NO.	VELOCITY MPH	MACH NO.	COEFFICIENT OF LIFT	COEFFICIENT OF DRAG	CATAPULT VELOCITY ft/sec	SEAT ATTITUDE	DISCREPANCY BETWEEN ACTUAL and CALCULATED HEIGHT AT FIN	
1	593	.780	-0.45	1.436	M-1 56		Calculated 8.20 Actual 7.60	0.6
2	578	.768	-0.25	1.424	NAMC 58		Calculated 11.35 Actual 11.00	0.35
3	660	.877	-0.5	1.546	NAMC 58		Calculated 4.45 Actual 2.70	1.75
6	470	.624	0	1.076	M-1 56	Rotating	Calculated 23.60 Actual 24.00	0.4

TEST NUMBER 5

Approximately 1.25 seconds after ignition the test carriage left the track and was destroyed. For possible causes of the malfunction see Test Nr 5, Appendix I. No data was obtained. Figure 39 shows the destroyed test carriage.

TEST NUMBER 6

This was a calibration run intended to compare the trajectory of this test with the trajectory of an aircraft ejection. The results of the test are given in Figures 40, 41 and 29. The seat tumbling was more pronounced than in other tests.

The retard rockets ignited prematurely on this test, causing the carriage to leave the track after it had left the test area, Figure 42.

TEST NUMBER 7

Premature retard rocket ignition (See Test Nr 7, Appendix I) caused clouds of rocket smoke which obscured the test carriage throughout the test area. Figure 43 is a film strip showing the dense clouds which accompanied the test. No data was therefore obtained.

CONCLUSIONS

The instrumentation set-up employed on the tests will have to be revised for further testing purposes in order to obtain desired acceleration data. Ejection accelerations were not accurately determined because of one or all of the following factors:

1. Acceleration rocket "burn-out" occurred at or near station of seat ejection.

2. Porpoising of test vehicle because of clearance between vehicle slippers and railhead.

3. Elastic structure of ejection seat.

4. Stretching of harness assembly which held dummy in ejection seat.

5. Elastic structure of test vehicle.

The seat will have to be ejected while the test vehicle is in a state of zero acceleration. The deceleration forces imposed on the test vehicle and ejection seat test configuration as the vehicle "coasted" through the track test section

were of such high magnitudes that "in-flight" seat trajectories could not be simulated. The resultant movement given to the ejected seat by the rails and gun of the catapult mechanism, during the deceleration period of the test vehicle, were such that the seat was kept nearly upright. The lift coefficient (see Table 4) was accordingly negative, the drag coefficient highter than under rotating conditions, and the resultant theoretical tail clearance was very small. Furthermore, deceleration forces in the order of seven "g's" were encountered during ejection and this tended to make the trajectory curves, as plotted from the original position of seat cg to a position immediately aft of the vertical fin of a particular airplane, appear as parabolic rather than asymptotic functions. Therefore a "ground" trajectory gave less horizontal separation between the seat and the airplane and less tail clearance than a comparative air borne trajectory. The bibliography refers to several reports from which "in-flight" trajectories for various airplanes can be obtained.

A practical conclusion that can be drawn from these tests is that the height (tail clearance) of the ejection seat trajectory will be decreased if the ejection occurs during certain combinations of aircraft deceleration and high equivalent airspeed.

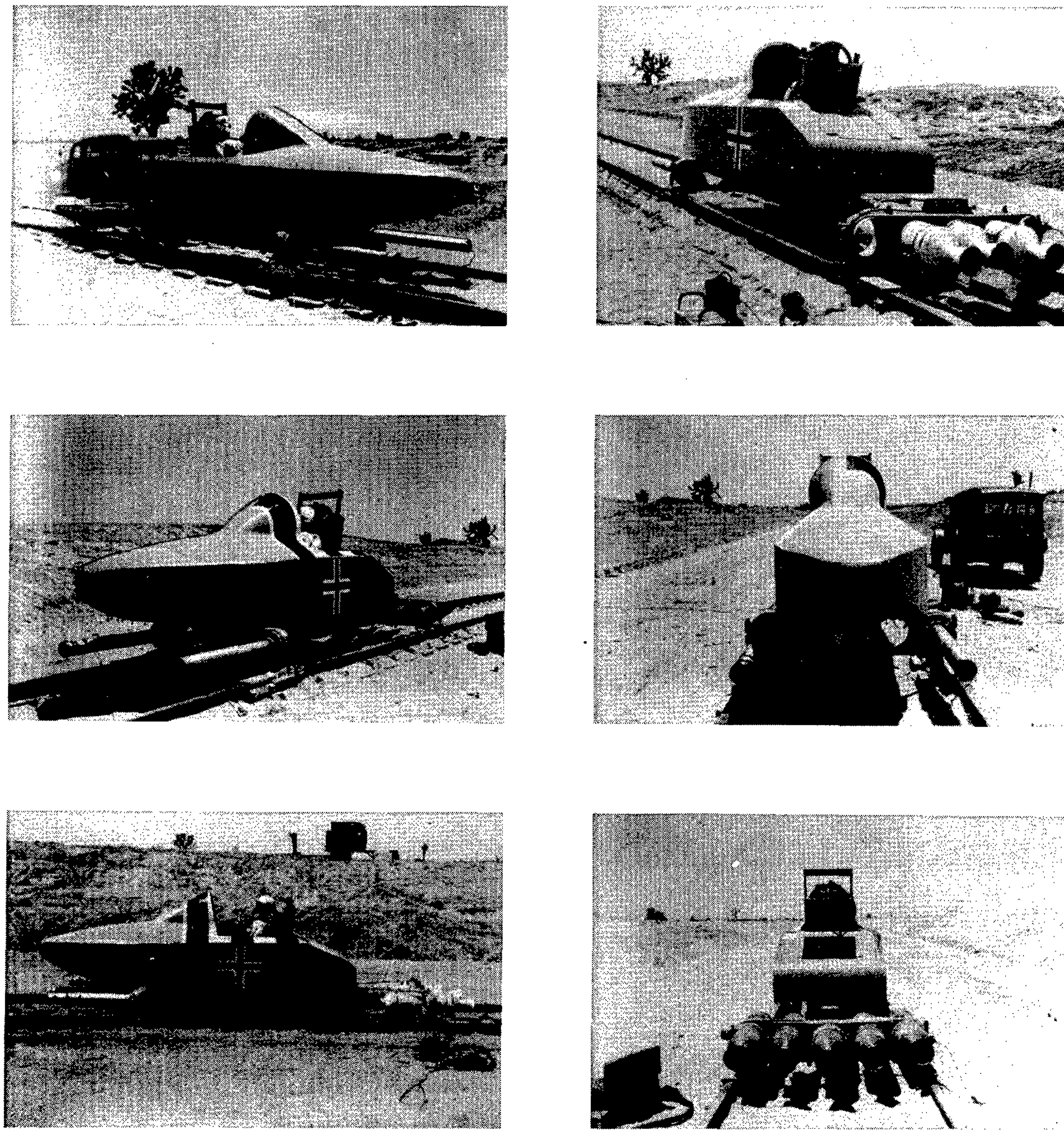


FIGURE I. GENERAL VIEWS OF TEST CARRIAGE ON TRACK.

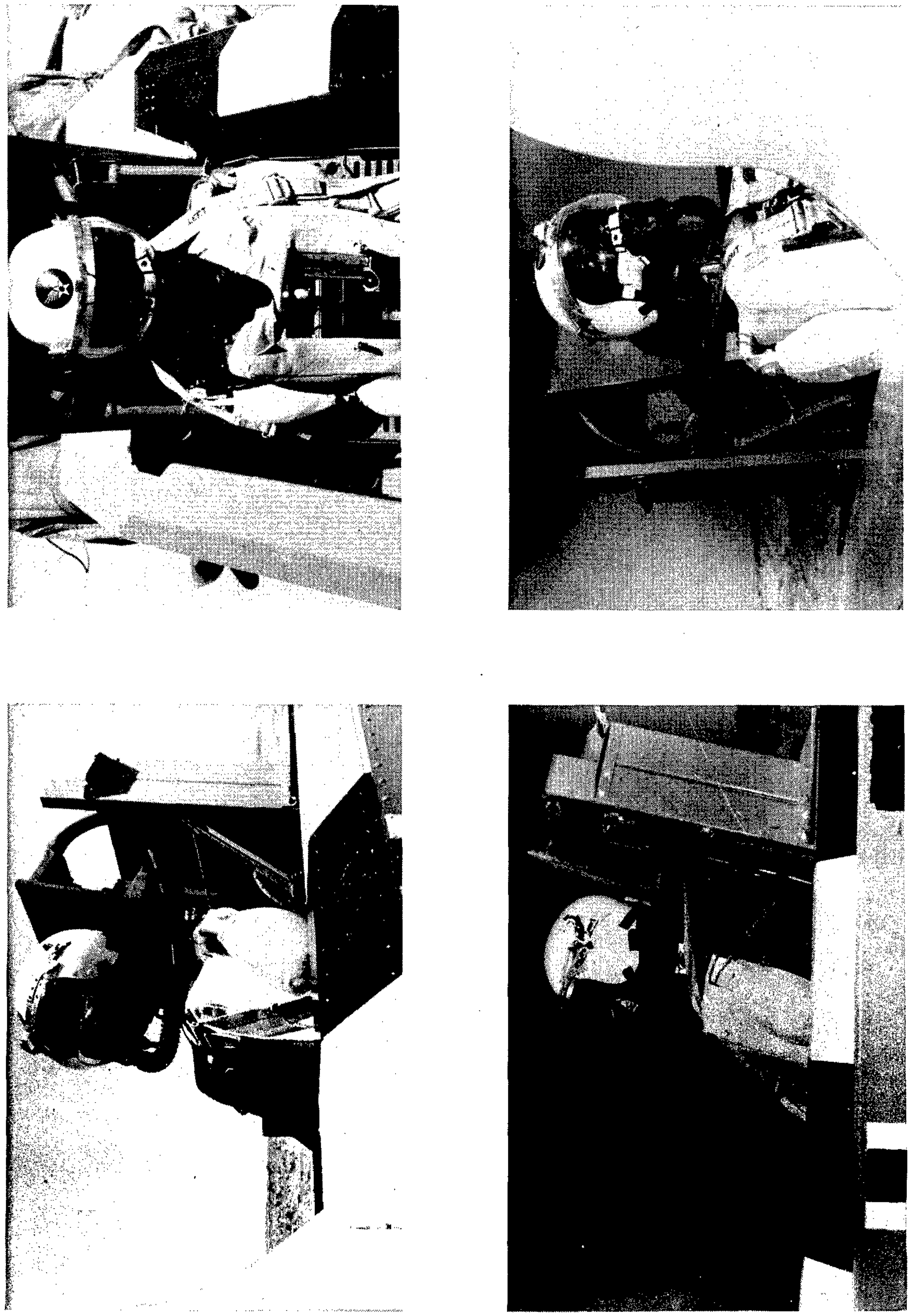


FIGURE 2. TEST CARRIAGE. XF-89, COCKPIT MOCK-UP.

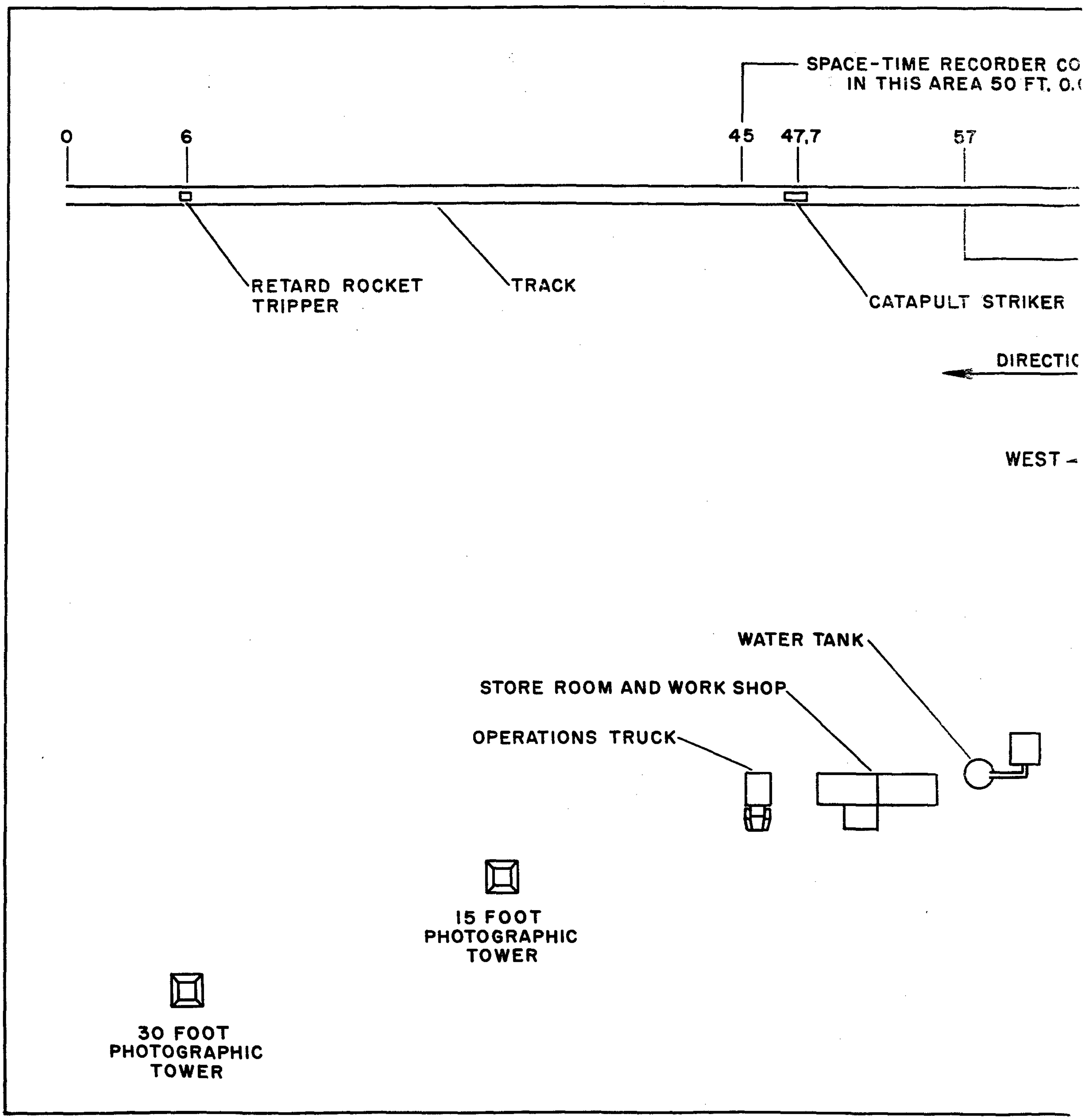
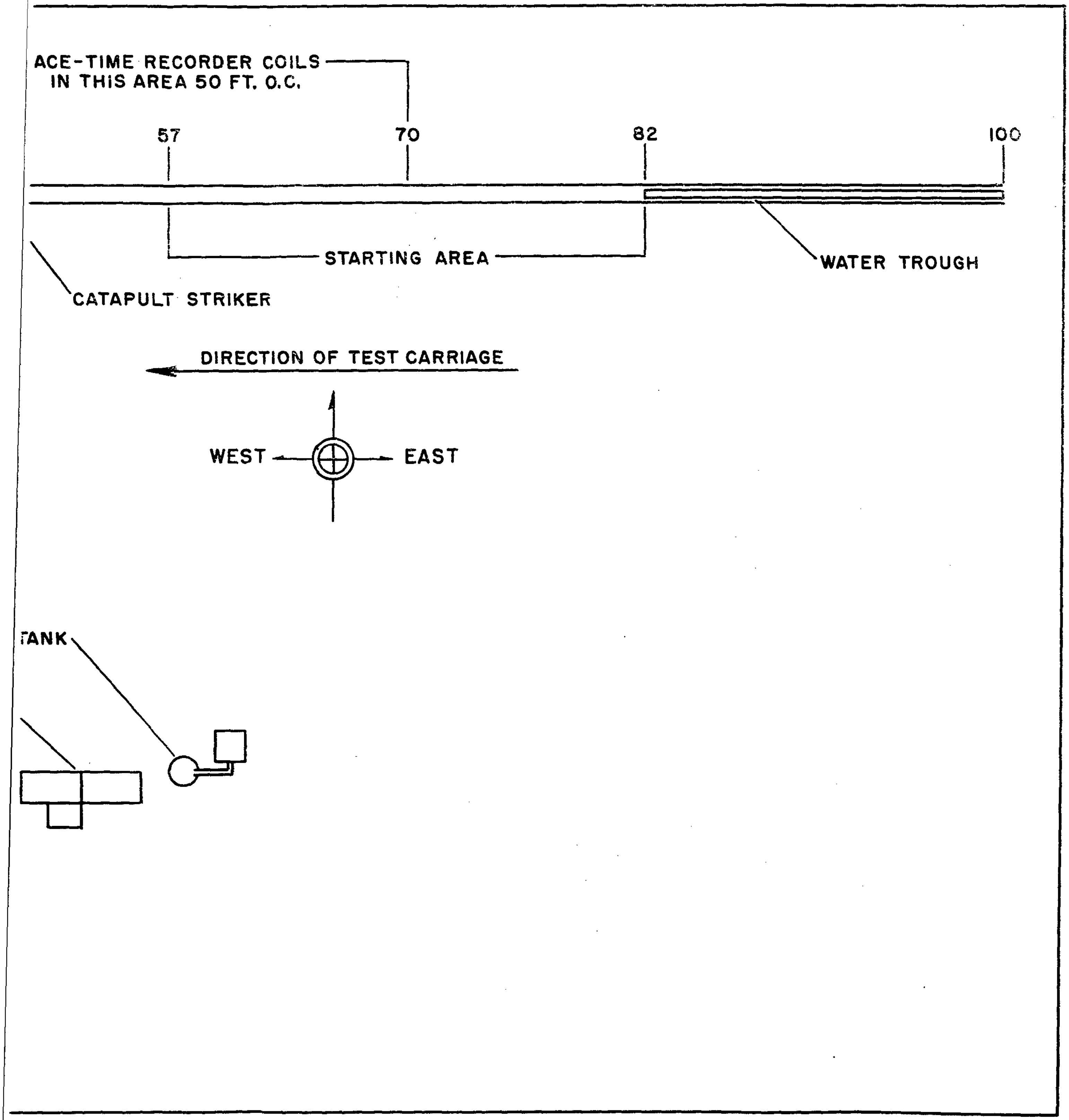


FIGURE 3. TEST AREA LAYOUT


ACE-TIME RECORDER COILS
IN THIS AREA 50 FT. O.C.
57
70
82
100
STARTING AREA
WATER TROUGH
CATAPULT STRIKER
DIRECTION OF TEST CARRIAGE
WEST
EAST
TANK

2

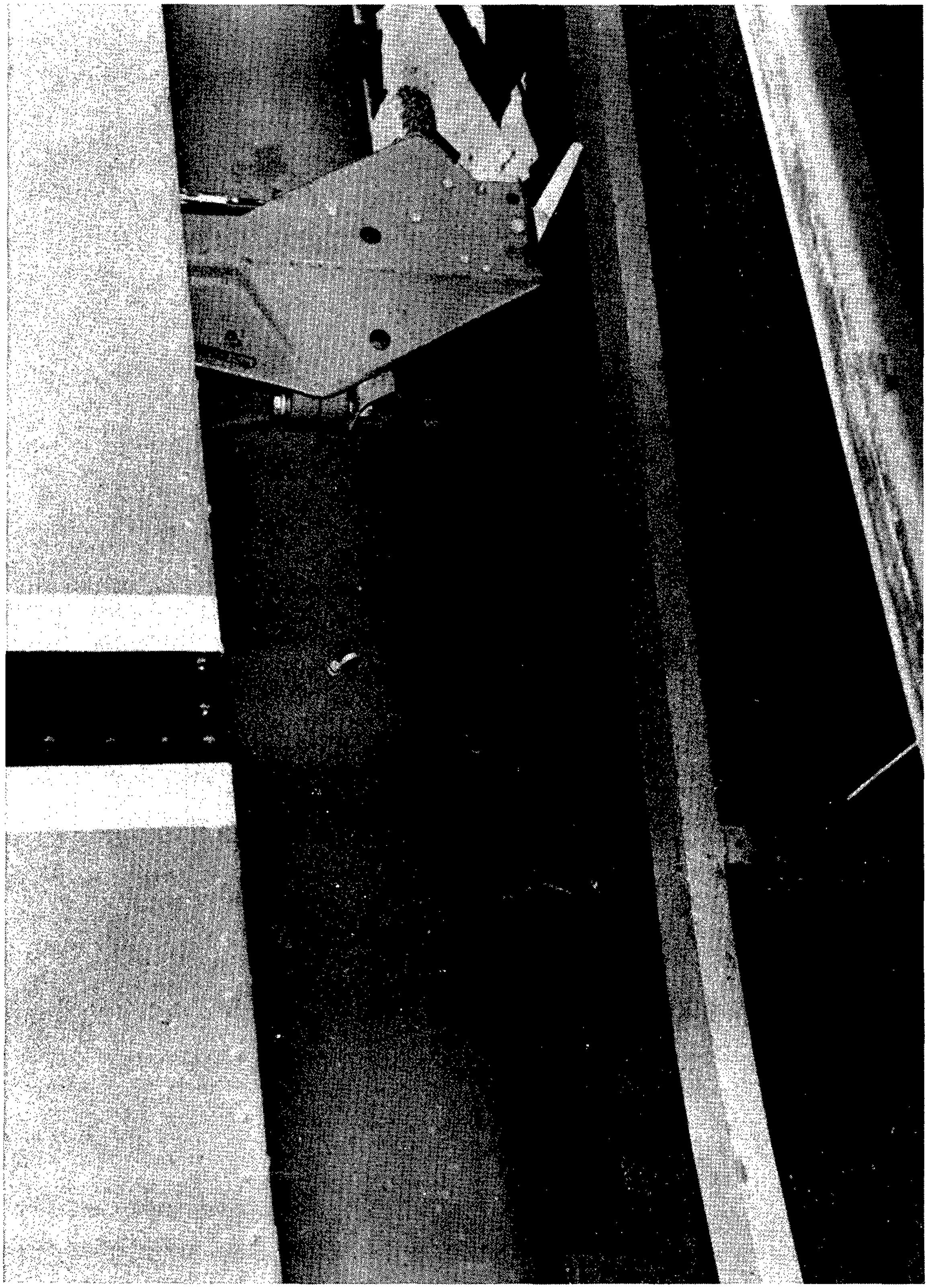


FIGURE 4. CATAPULT STRIKER ASSEMBLY MOUNTED BETWEEN TRACK RAILS.

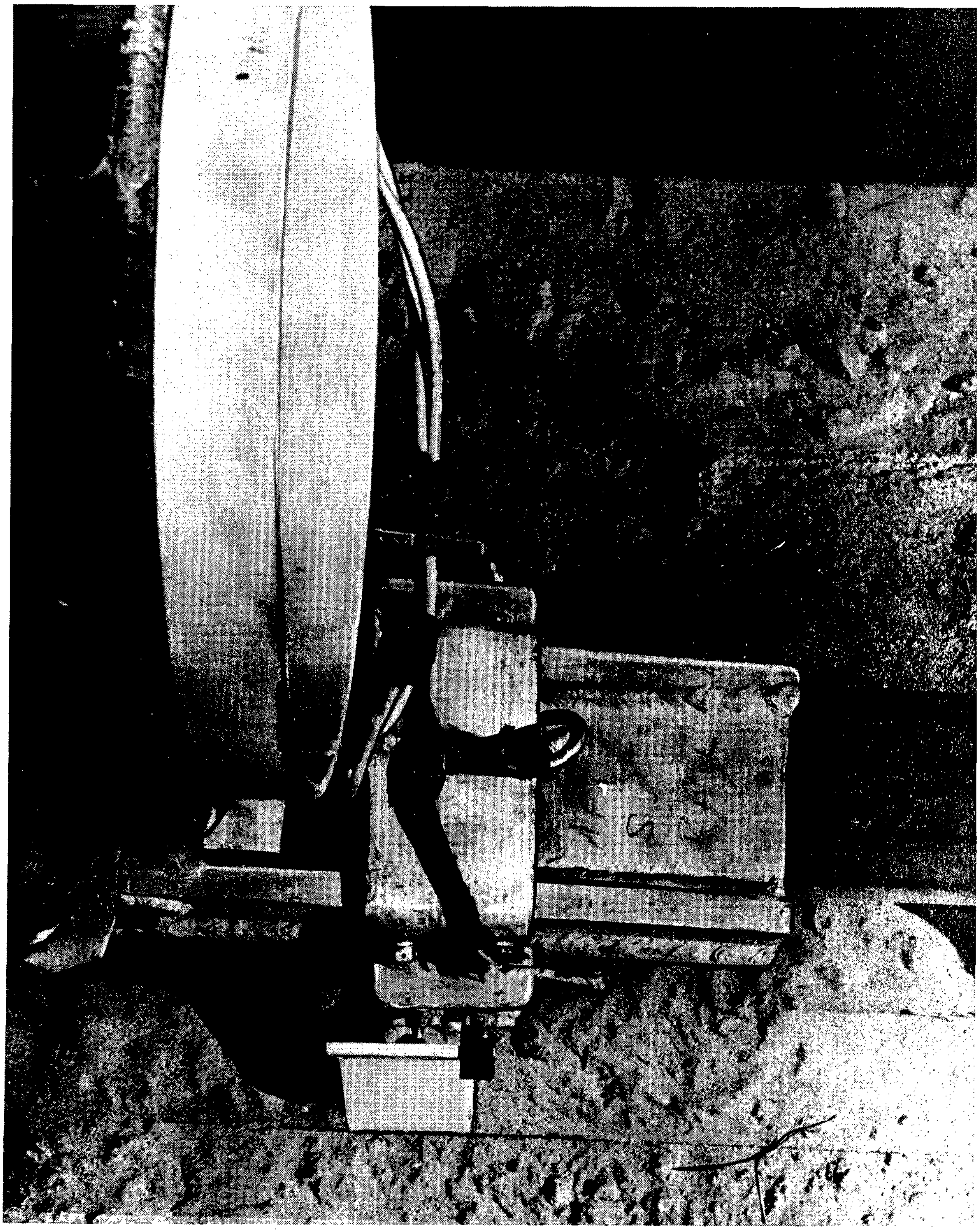


FIGURE 5. RETARD ROCKET STRIKER.

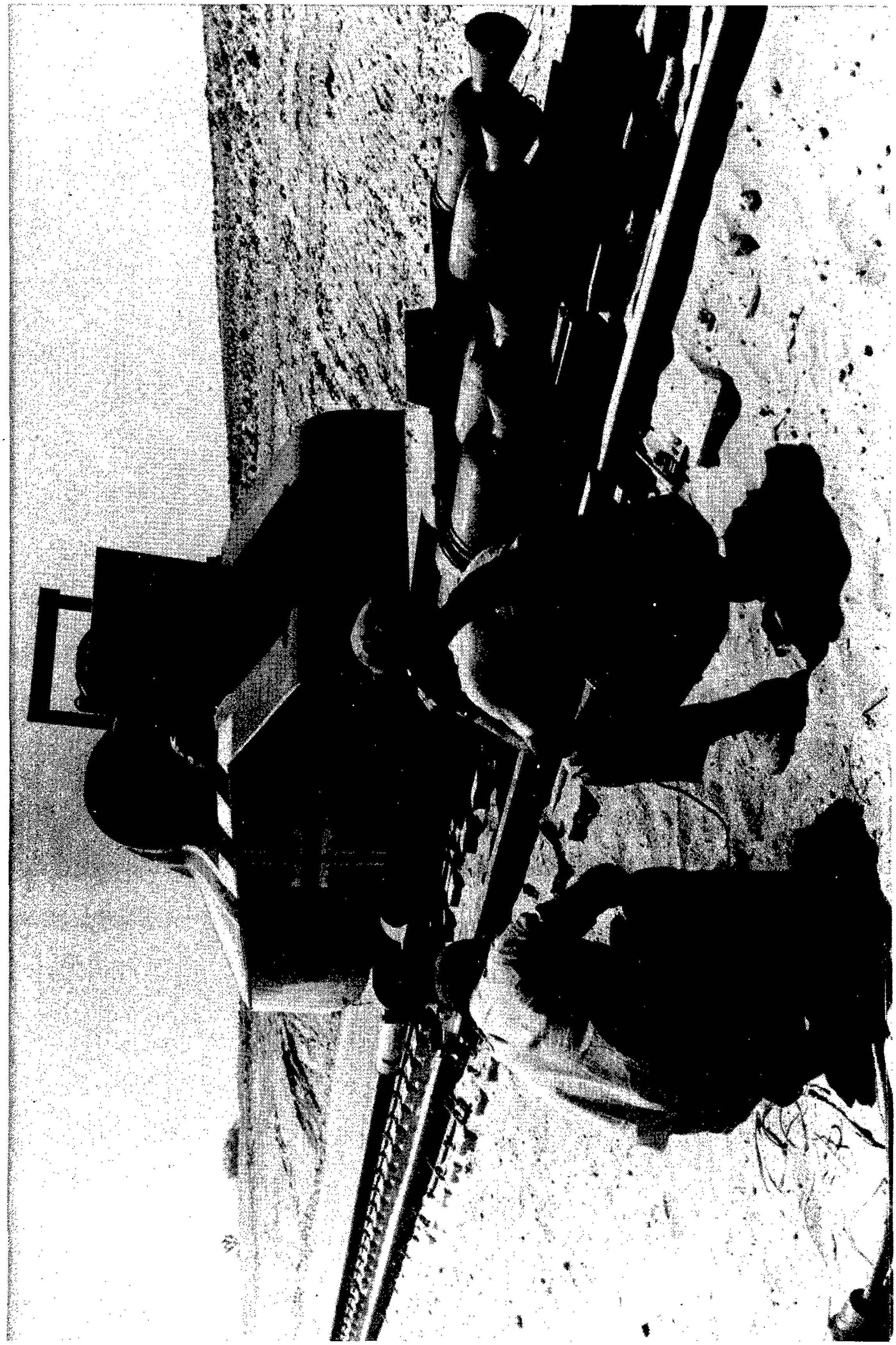


FIGURE 6. HINGED DOOR PROVIDING ACCESS TO ELECTRICAL EQUIPMENT COMPARTMENT.

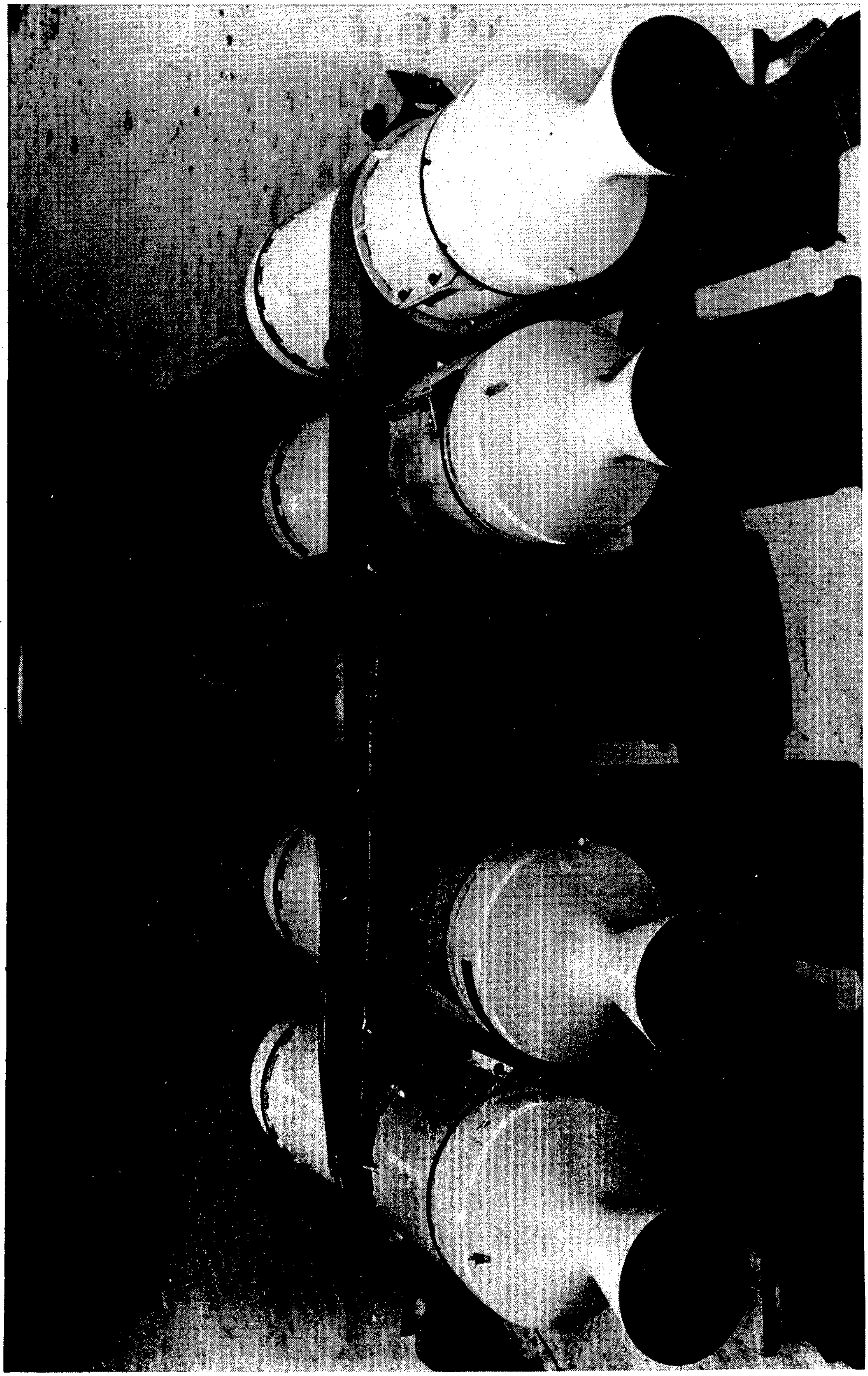


FIGURE 7. PROPULSION ROCKETS INSTALLATION.

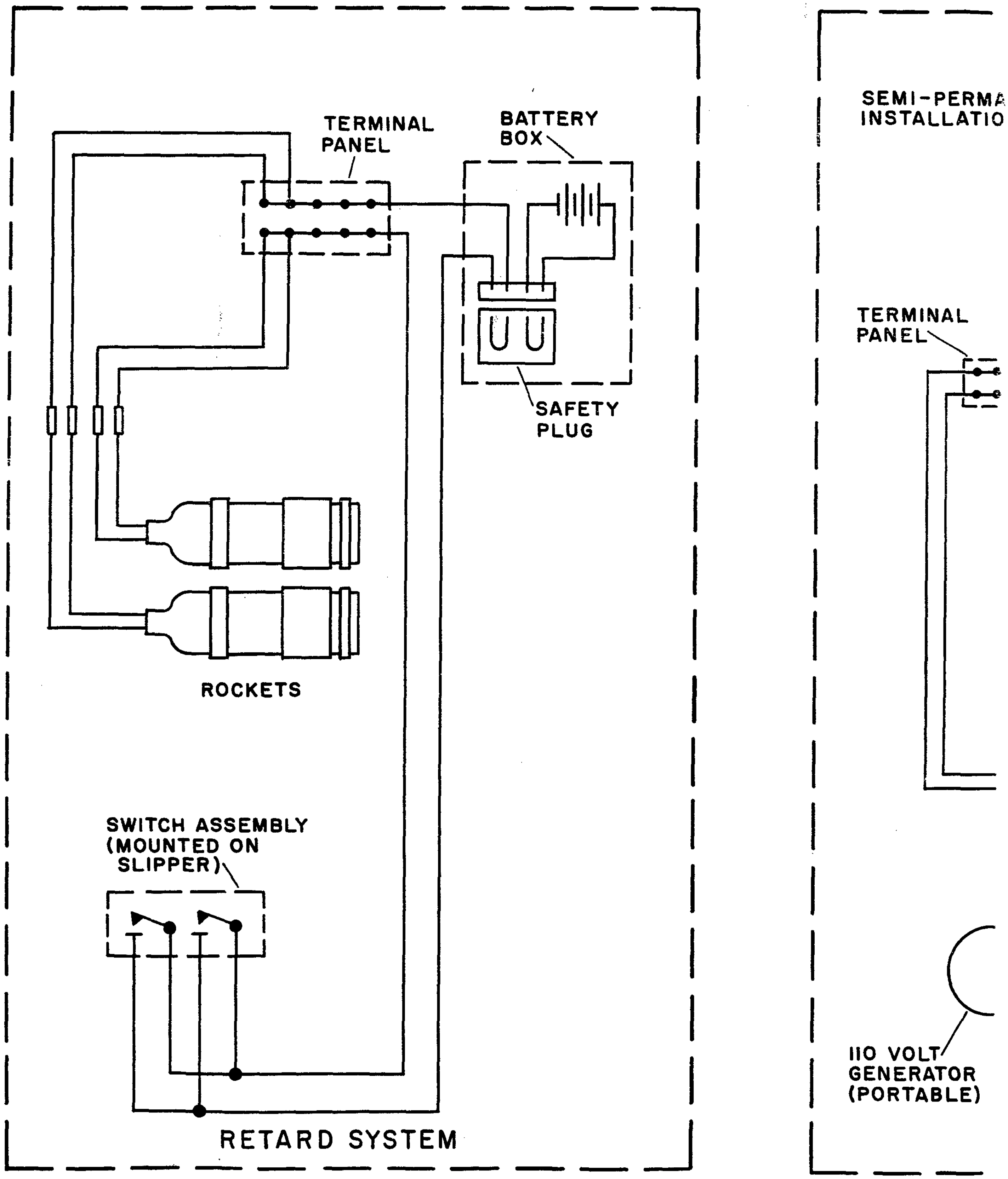
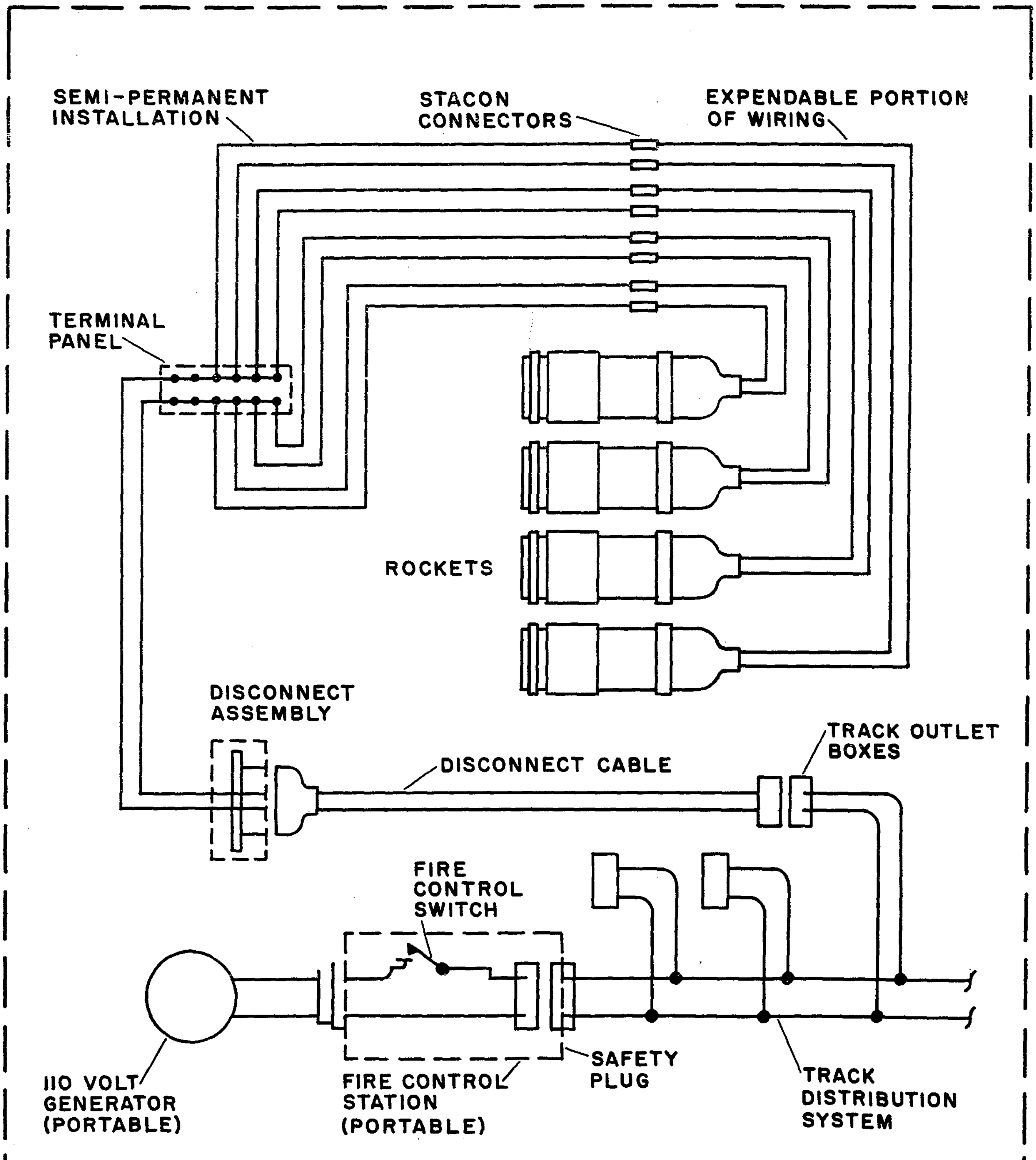


FIGURE 8. ROCKET WIRING DIAGRAMS.



PROPELLING SYSTEM

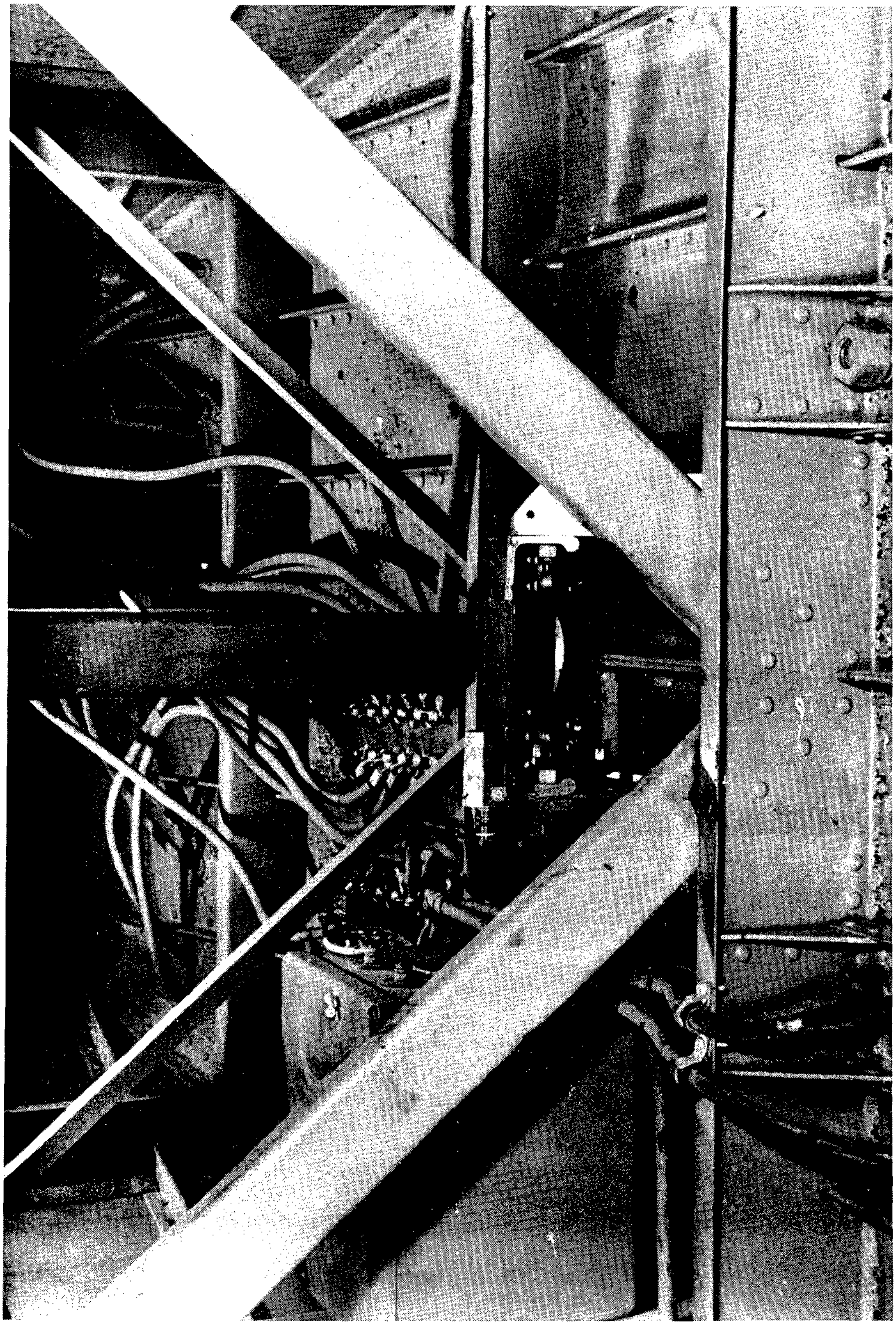


FIGURE 9. RETARD ROCKET POWER SUPPLY INSTALLATION.

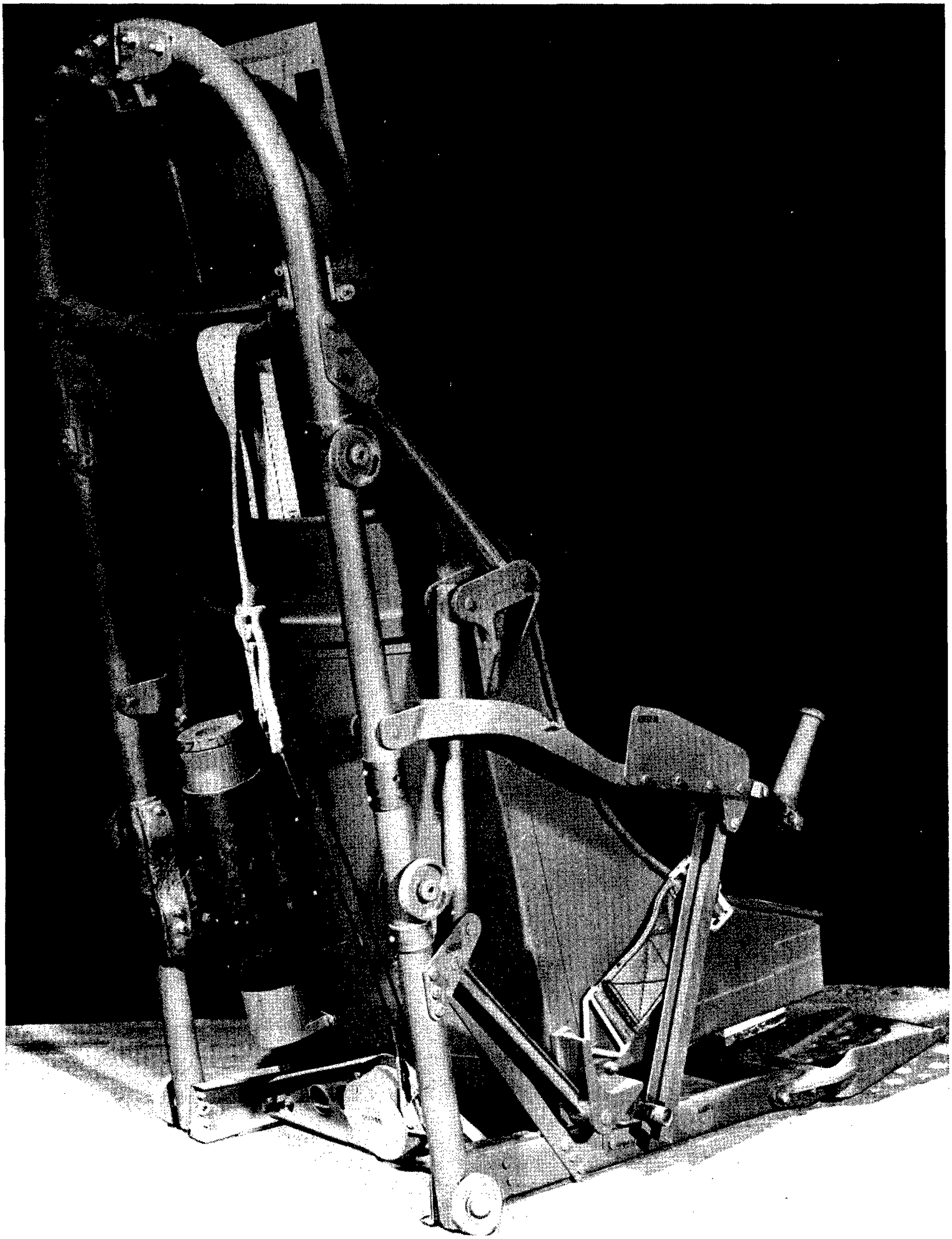


FIGURE 10. MODIFIED XF-89 PILOT EJECTION SEAT.

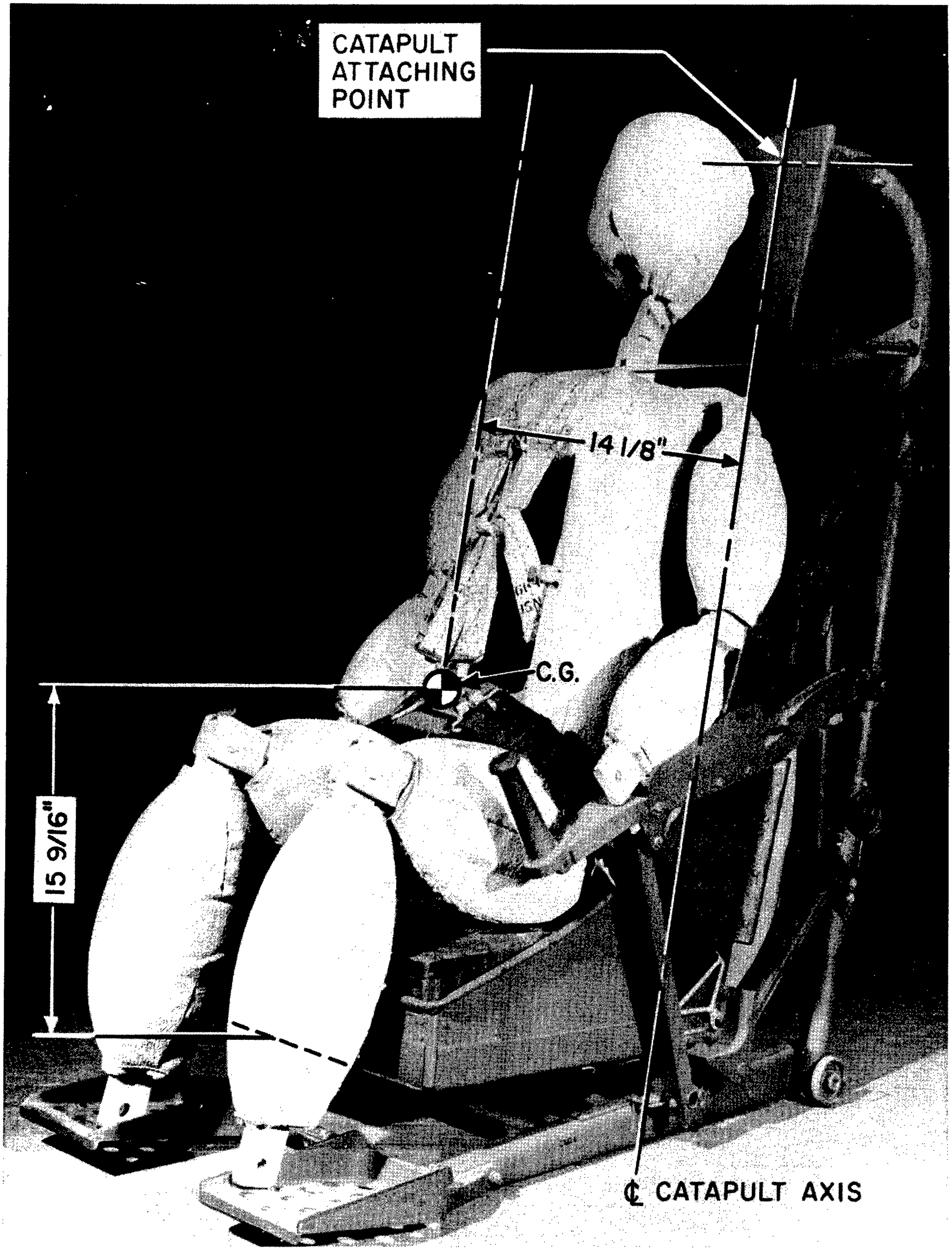


FIGURE 11. DUMMY INSTALLATION AND CENTER OF GRAVITY LOCATION.

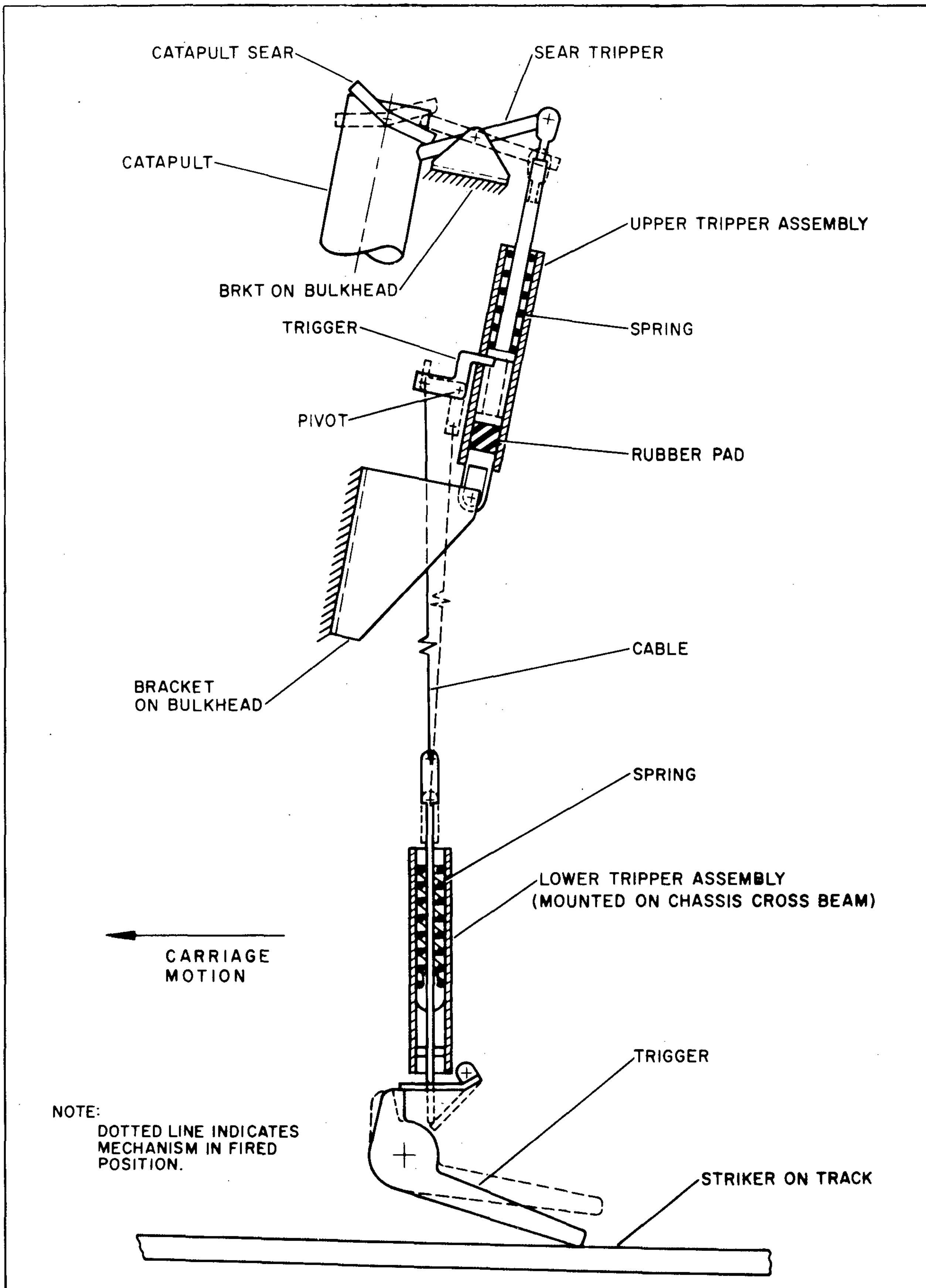


FIGURE 12. CATAPULT TRIPPING MECHANISM, TYPE T4E1 CATAPULT

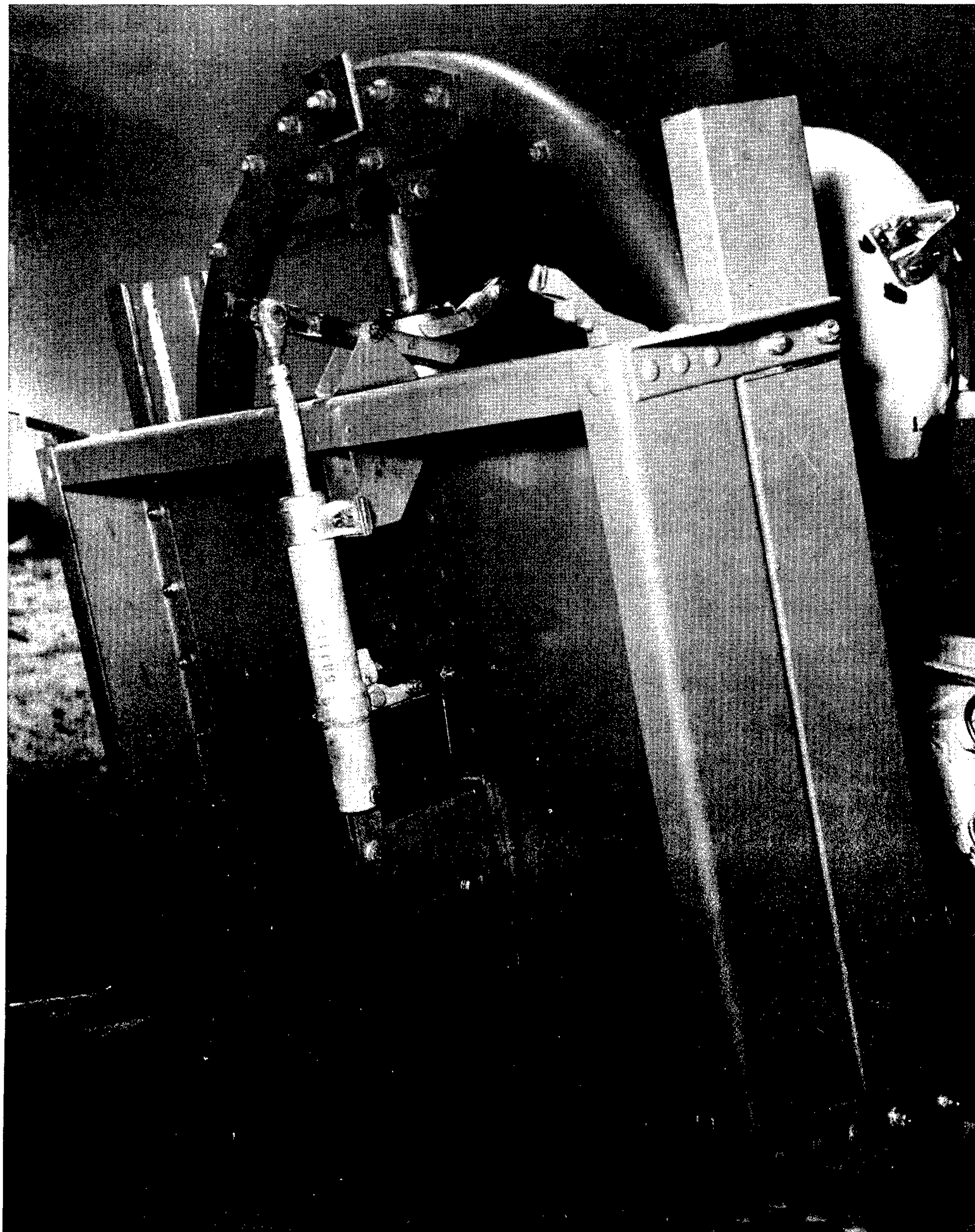


FIGURE 13. TYPE M-I CATAPULT RELEASE MECHANISM.

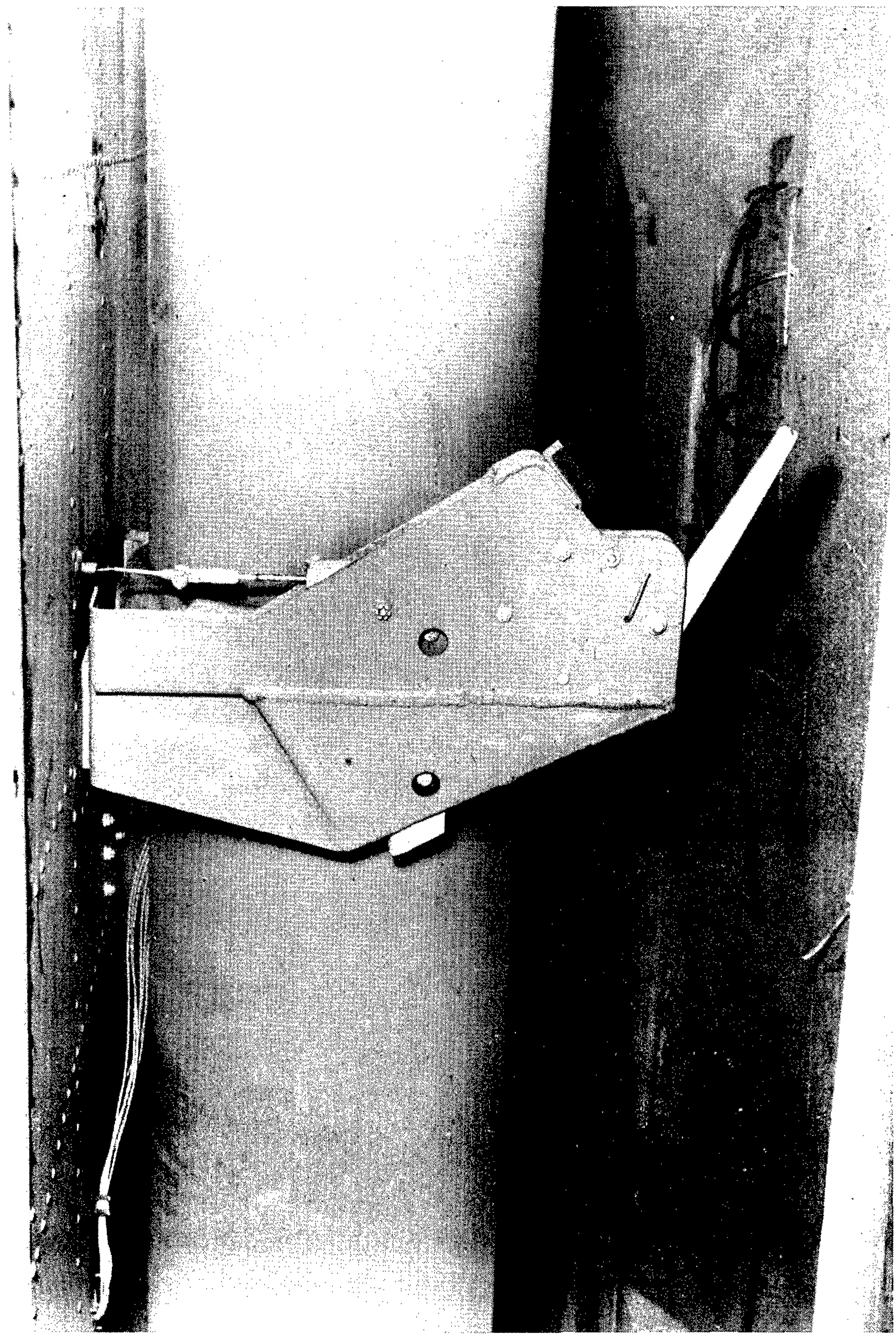


FIGURE 14. CATAPULT TRIGGER ASSEMBLY INSTALLATION ON CARRIAGE.

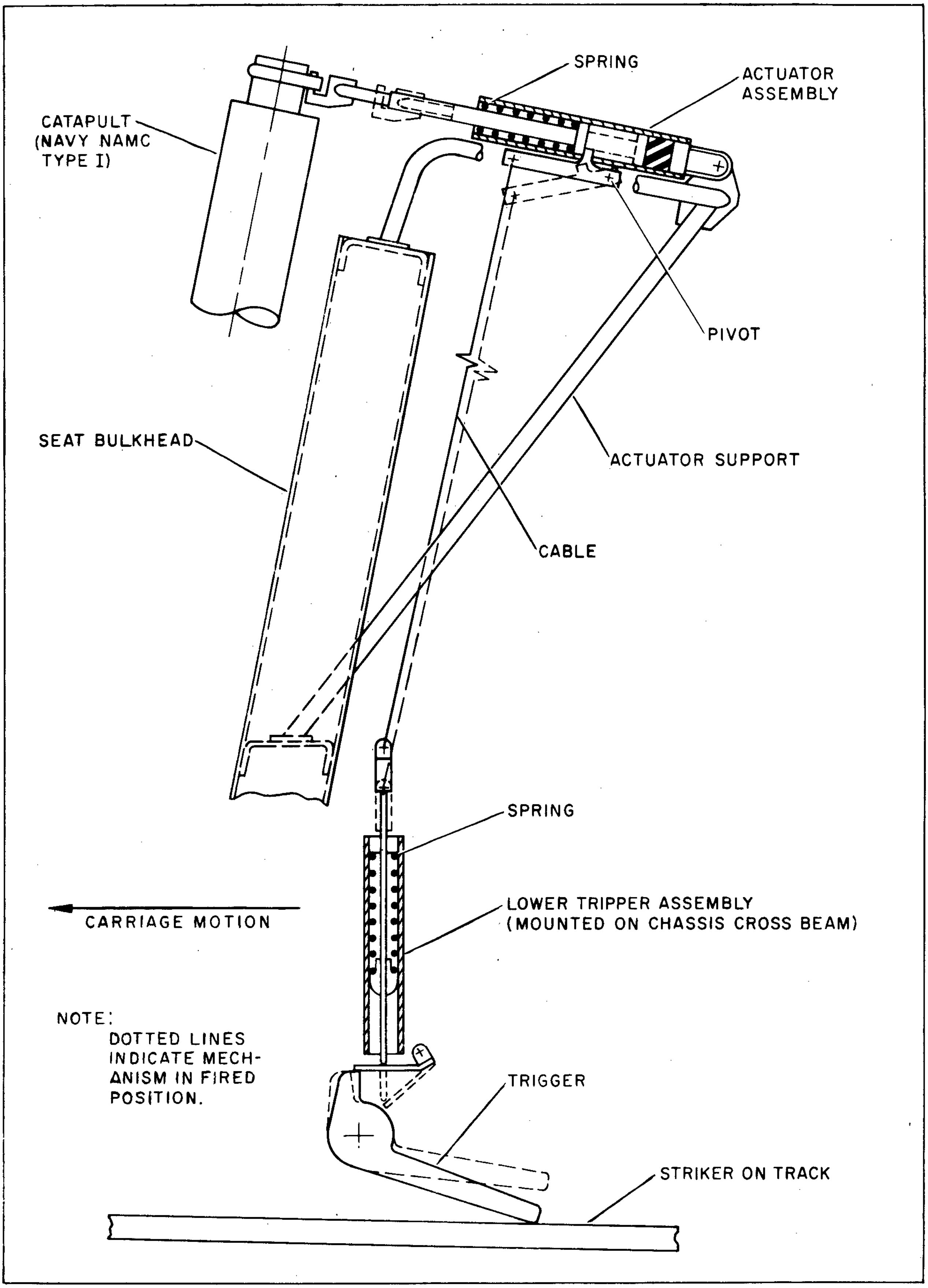


FIGURE 15. CATAPULT TRIPPING MECHANISM, NAVY NAMC TYPE I CATAPULT.

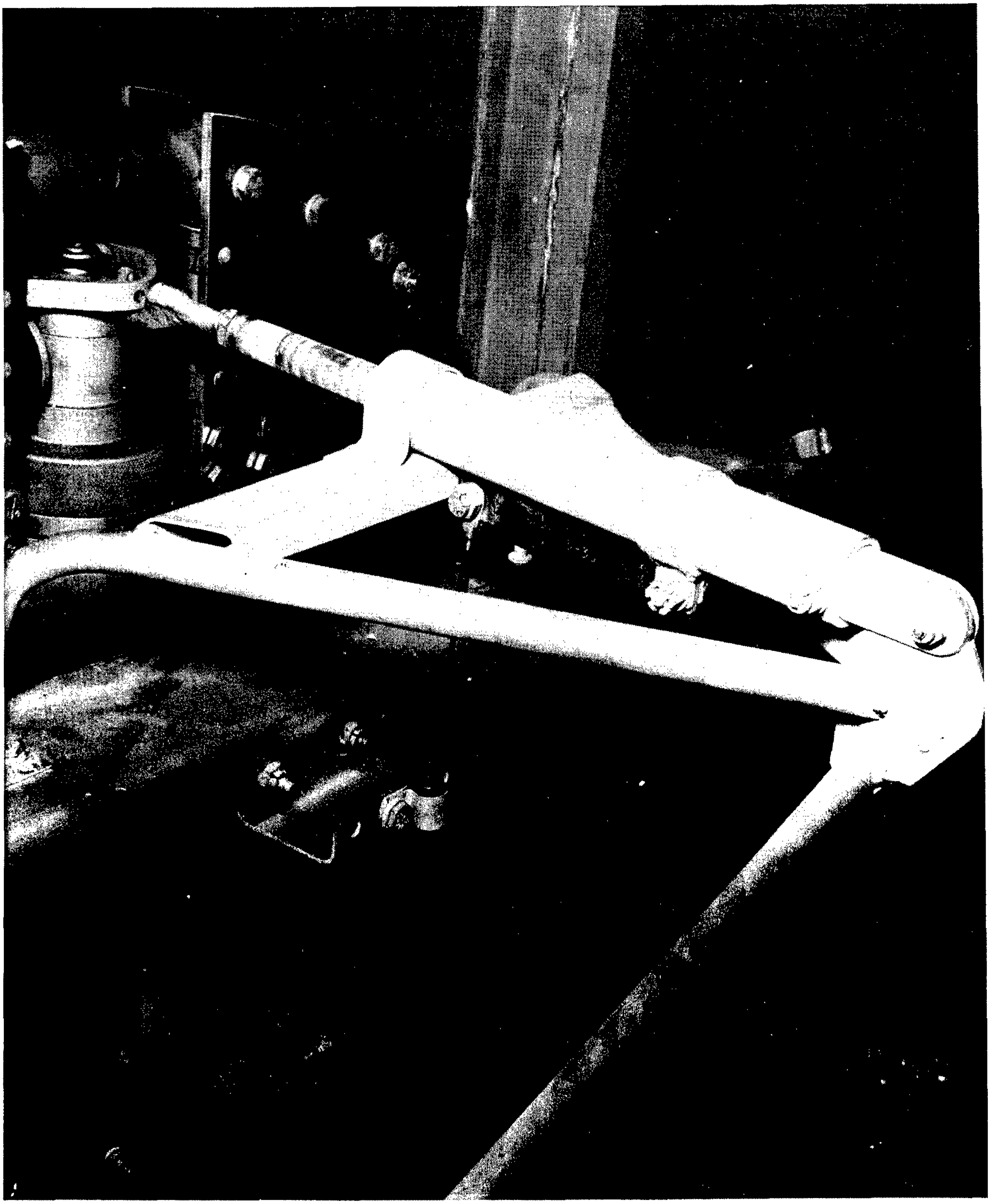


FIGURE 16. NAVY NAMC TYPE I CATAPULT, ACTUATOR INSTALLATION.

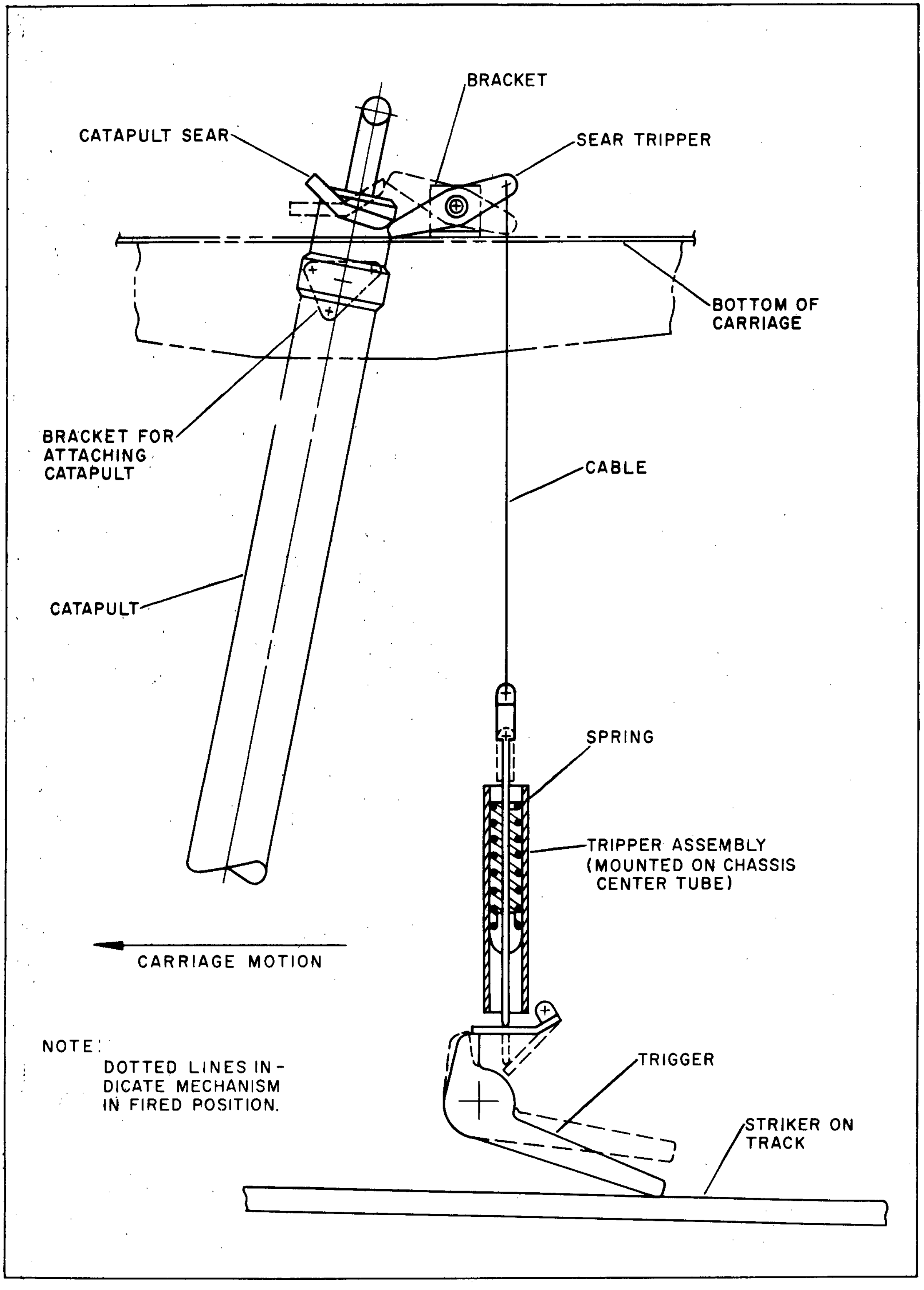


FIGURE 17. CATAPULT TRIPPING MECHANISM, RAISED ENCLOSURE MODIFICATION.

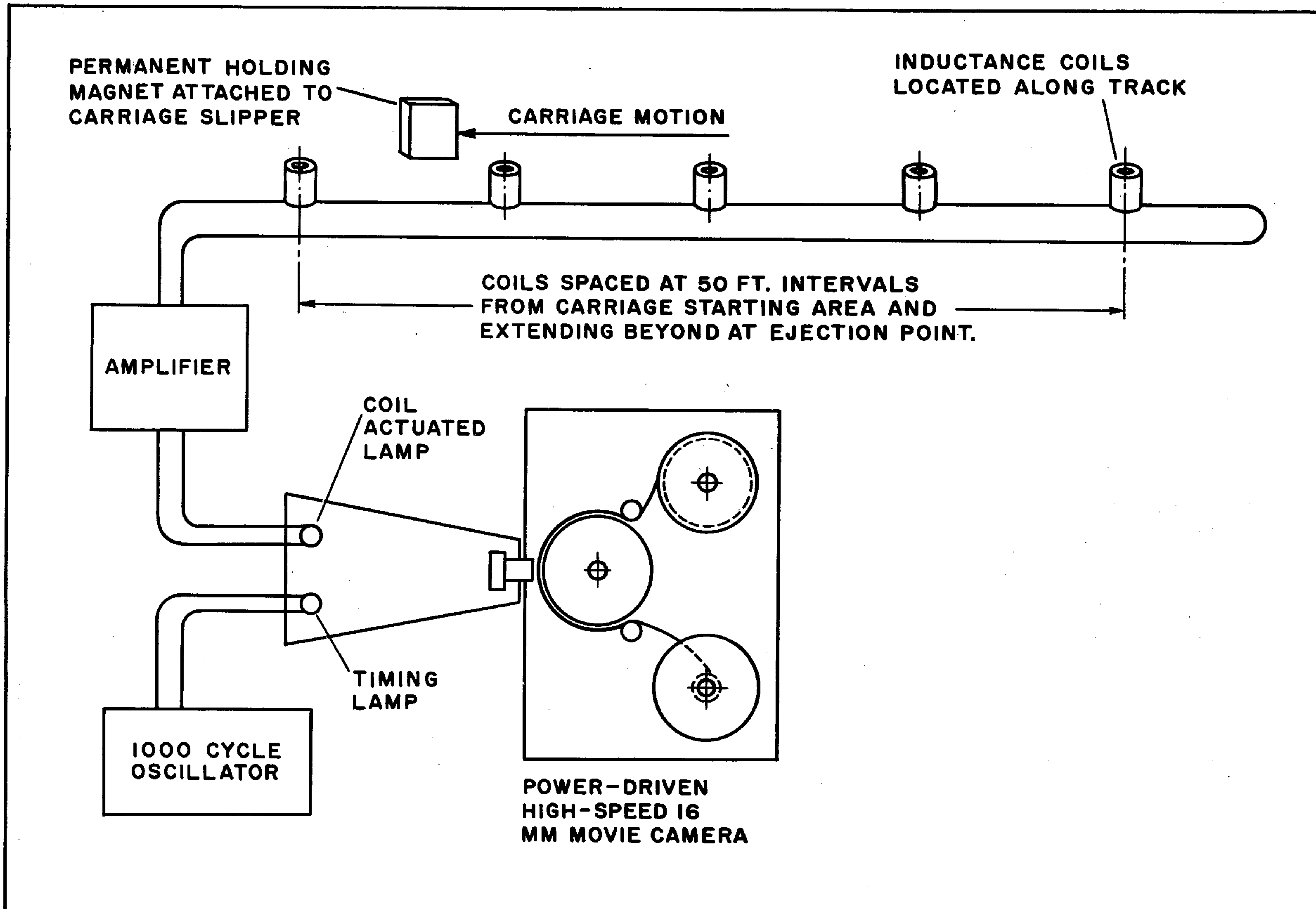


FIGURE 18. CARRIAGE MOTION RECORDING SYSTEM, MECHANICAL AND ELECTRICAL ARRANGEMENT.

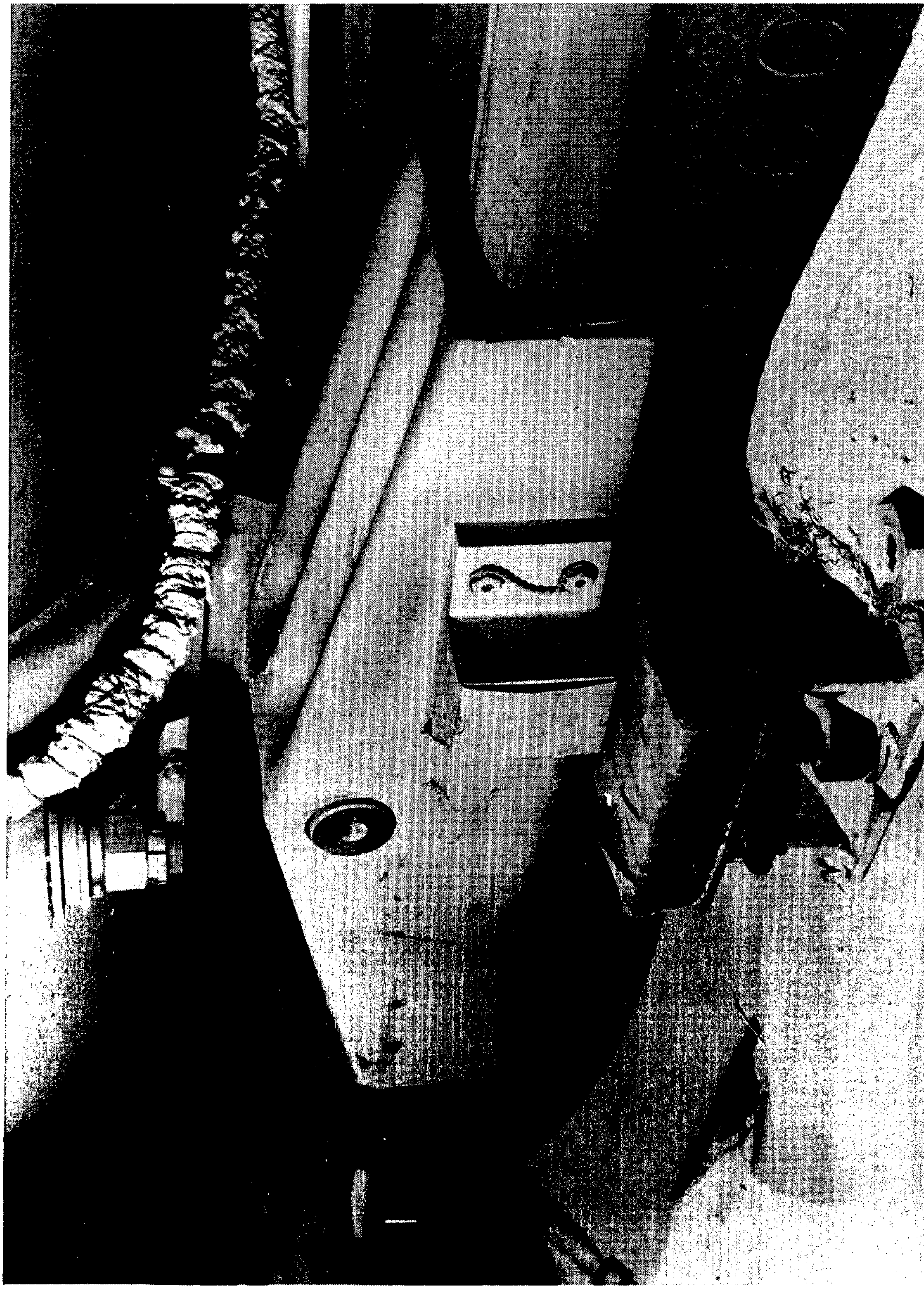


FIGURE 19. SPACE-TIME RECORDING INSTALLATION. TRACK AND SLIPPER MAGNET INSTALLATION.

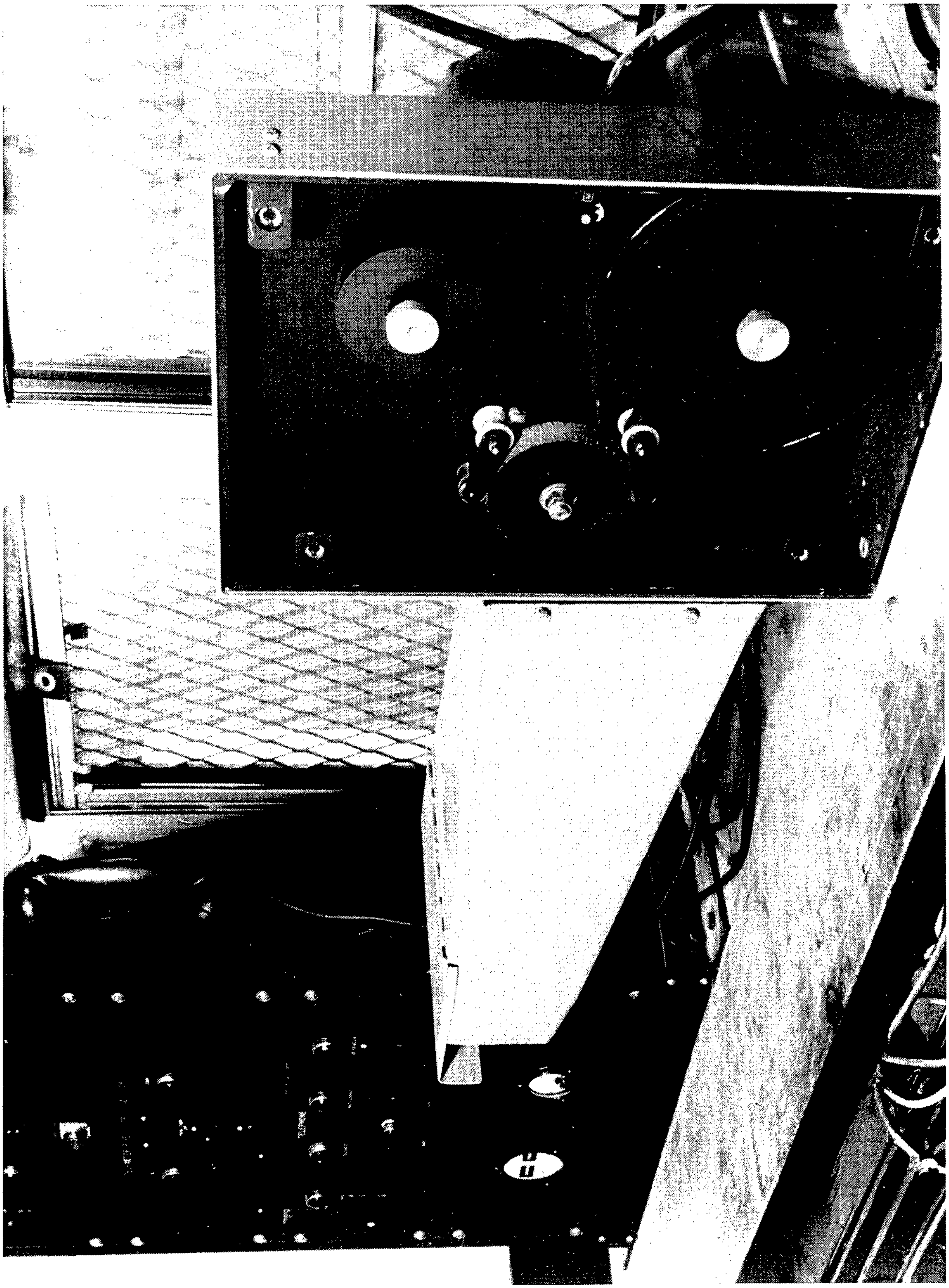


FIGURE 20. SPACE-TIME RECORDING CAMERA (COVER REMOVED).

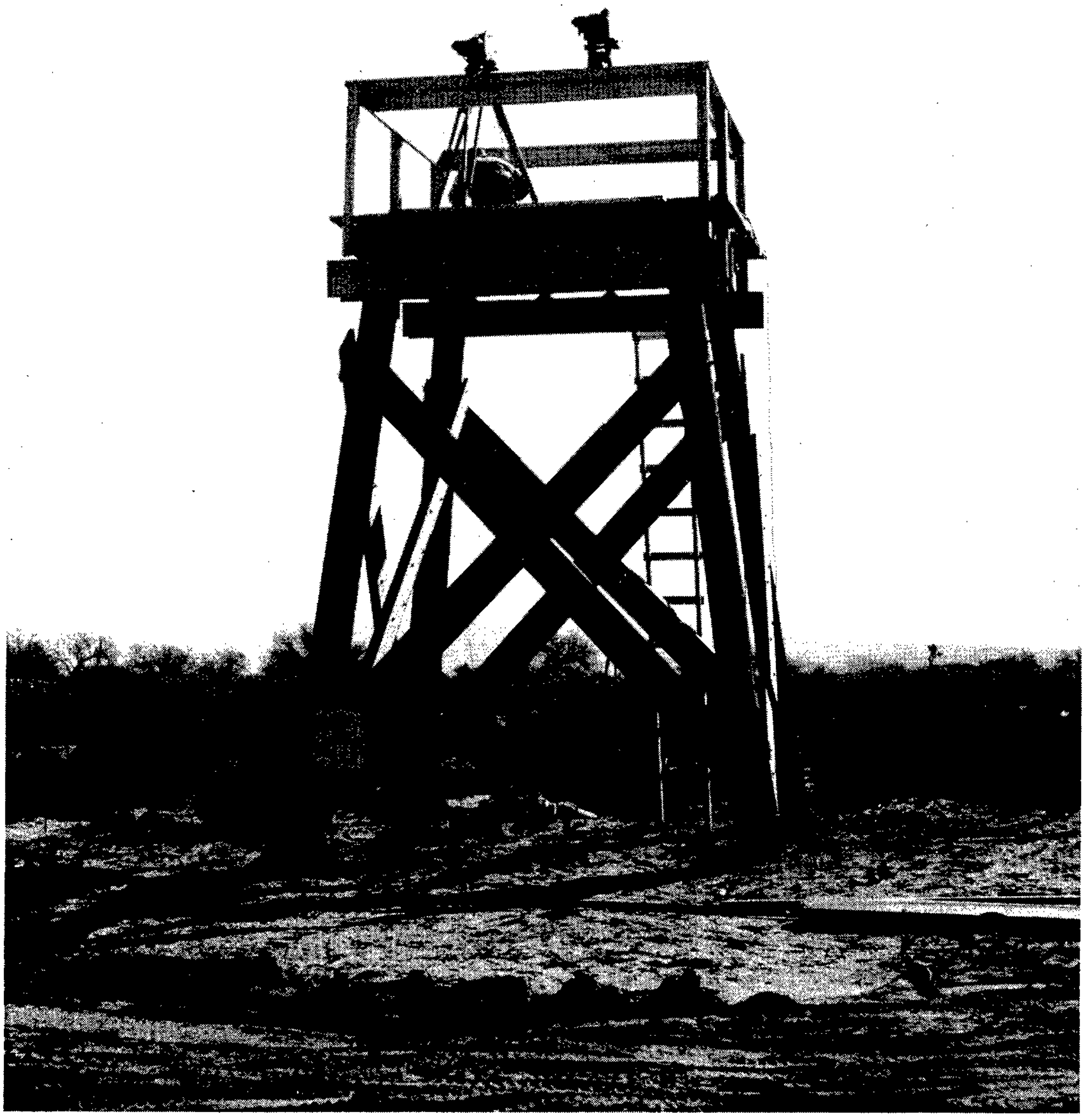


FIGURE 21. 15 FOOT PHOTOGRAPHIC TOWER; 375 FEET SOUTH AND 50 FEET WEST OF EJECTION STATION.

FIGURE 22. 30 FOOT PHOTOGRAPHIC TOWER; 750 FEET SOUTH AND 550 FEET WEST OF EJECTION STATION.

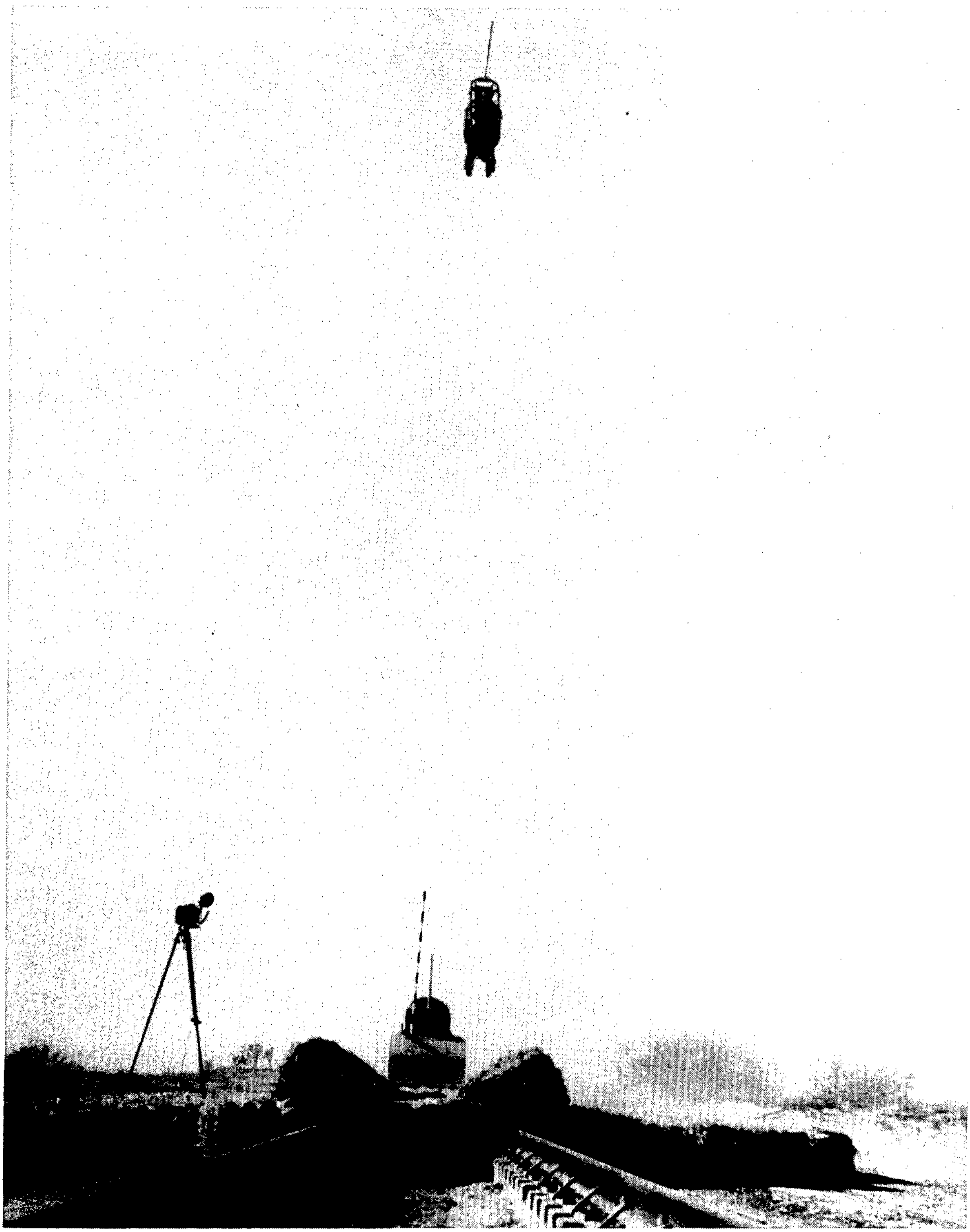


FIGURE 23. EJECTION TEST ; STATIC , NO. 2, PEAK HEIGHT REACHED BY DUMMY.

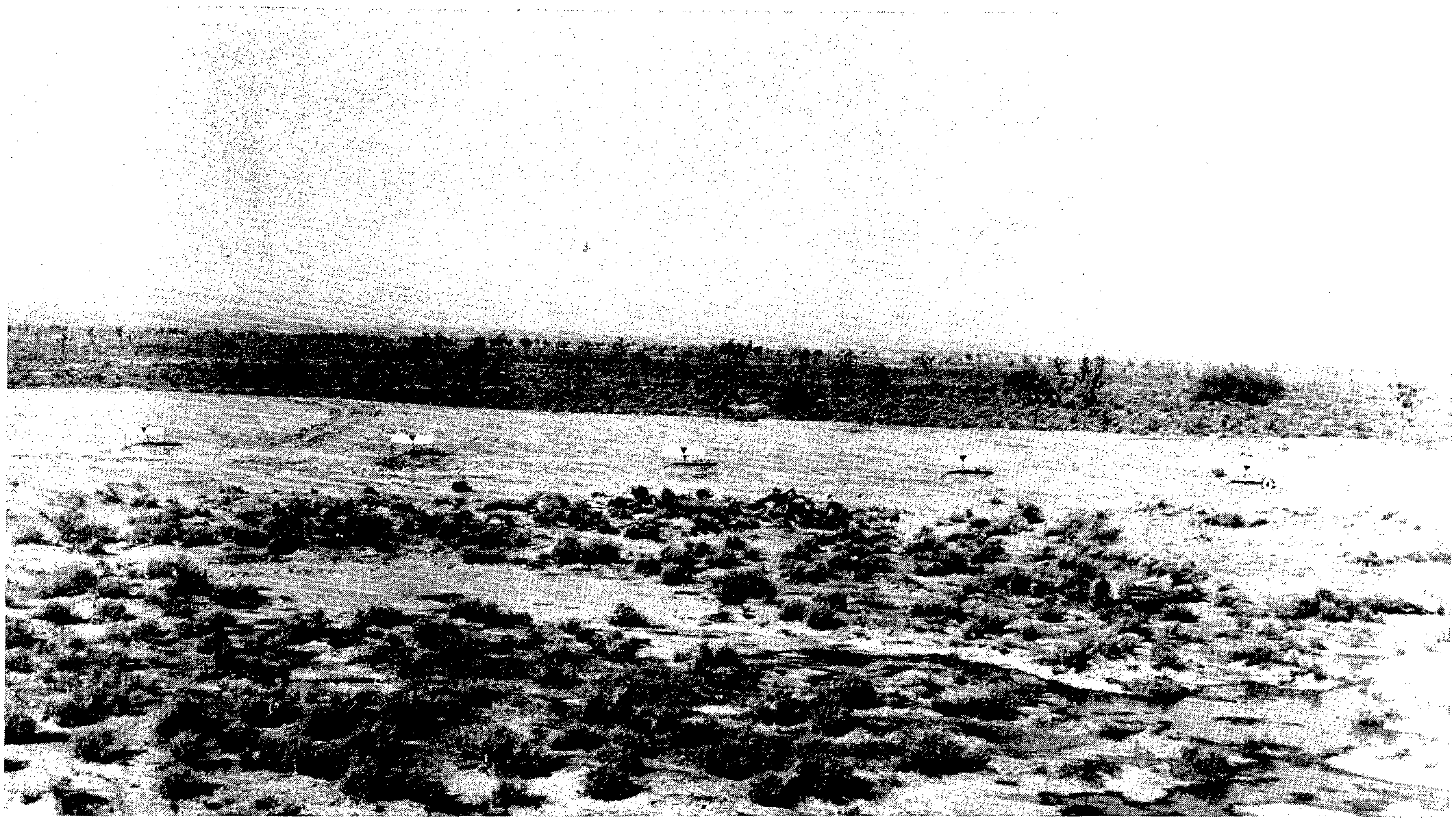


FIGURE 24. 50 FOOT PHOTO MARKERS, VIEW FROM 15 FOOT TOWER. "O" IS EJECTION STATION.

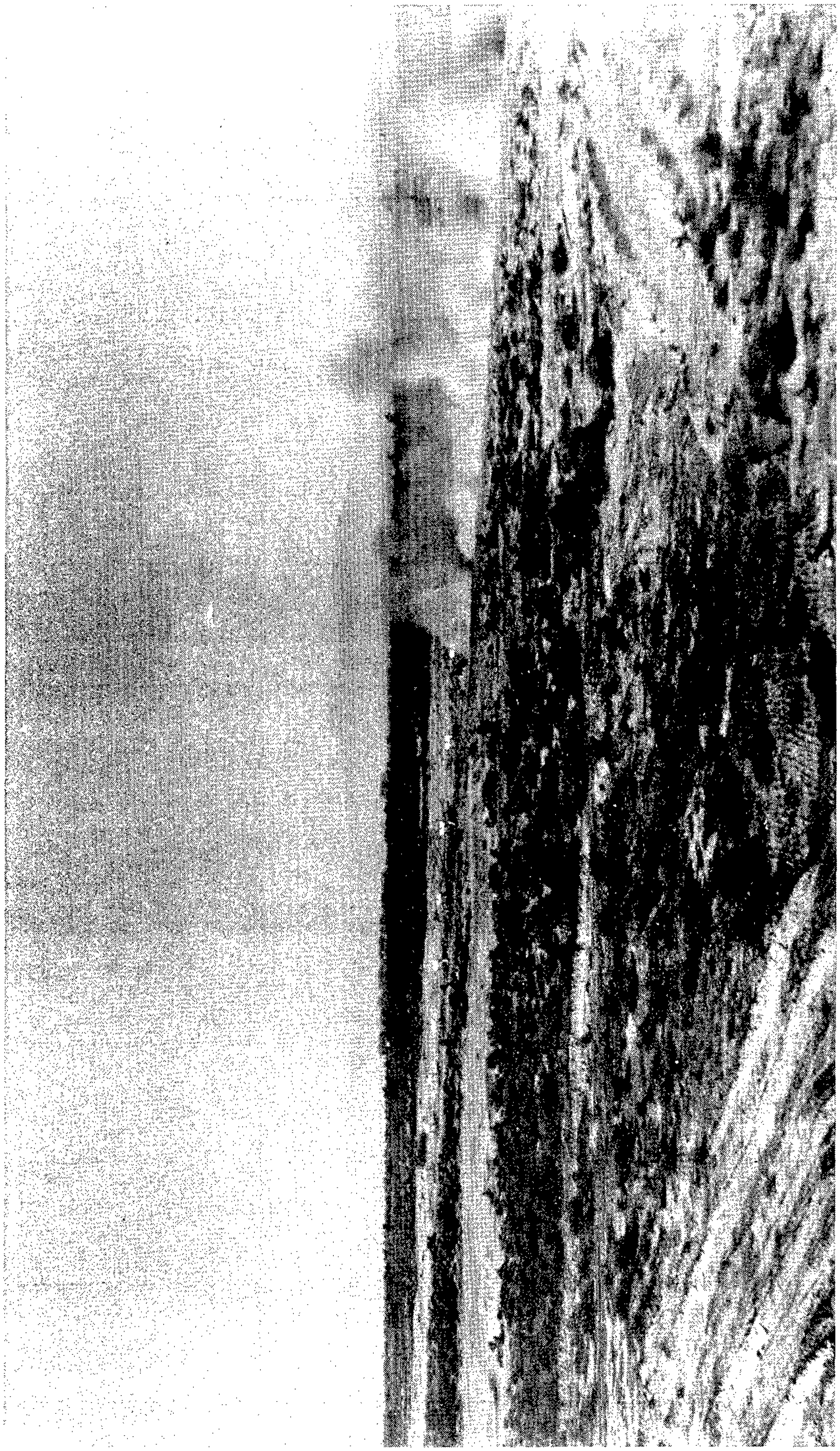


FIGURE 25. FIRING RUN OF EJECTION SEAT TEST CARRIAGE, CARRIAGE AT APPROXIMATELY 600 FEET BEYOND EJECTION STATION. REFERENCE MARKS OBSCURED BY FLAME OF RETARD ROCKETS.

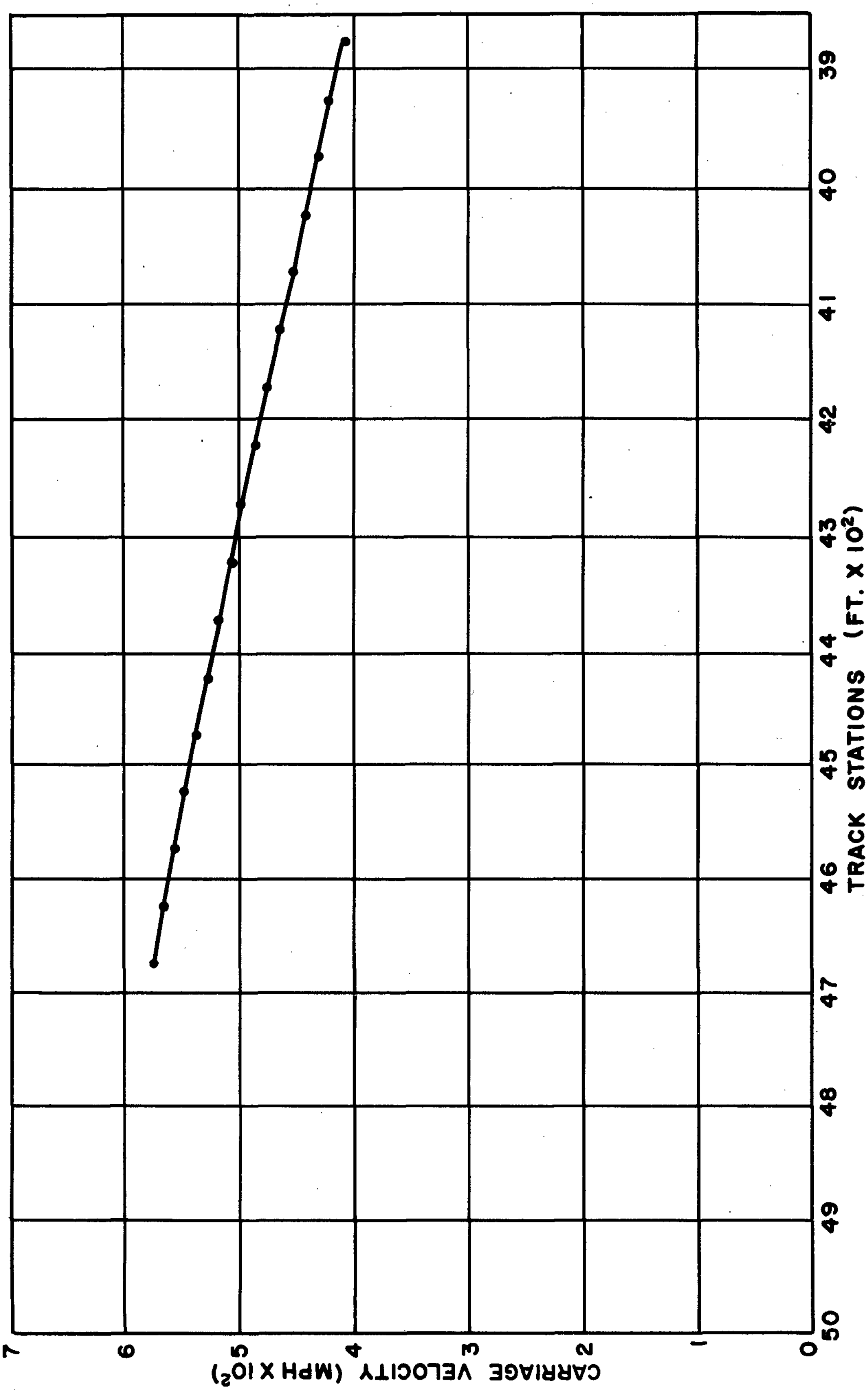


FIGURE 26. TEST I, CARRIAGE VELOCITY VS. TRACK STATIONS.

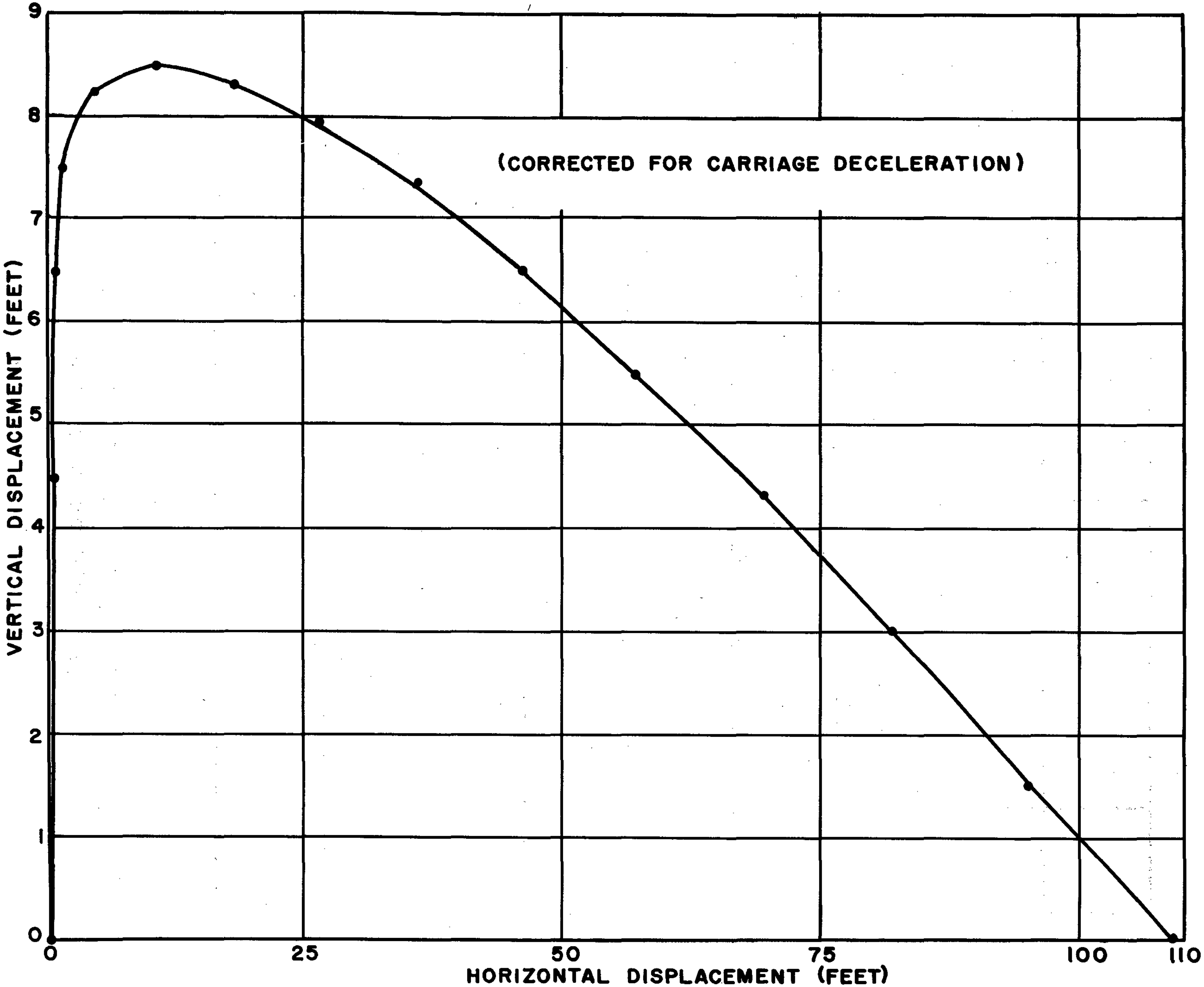


FIGURE 27. TEST I, TRAJECTORY OF DUMMY RELATIVE TO TEST CARRIAGE.

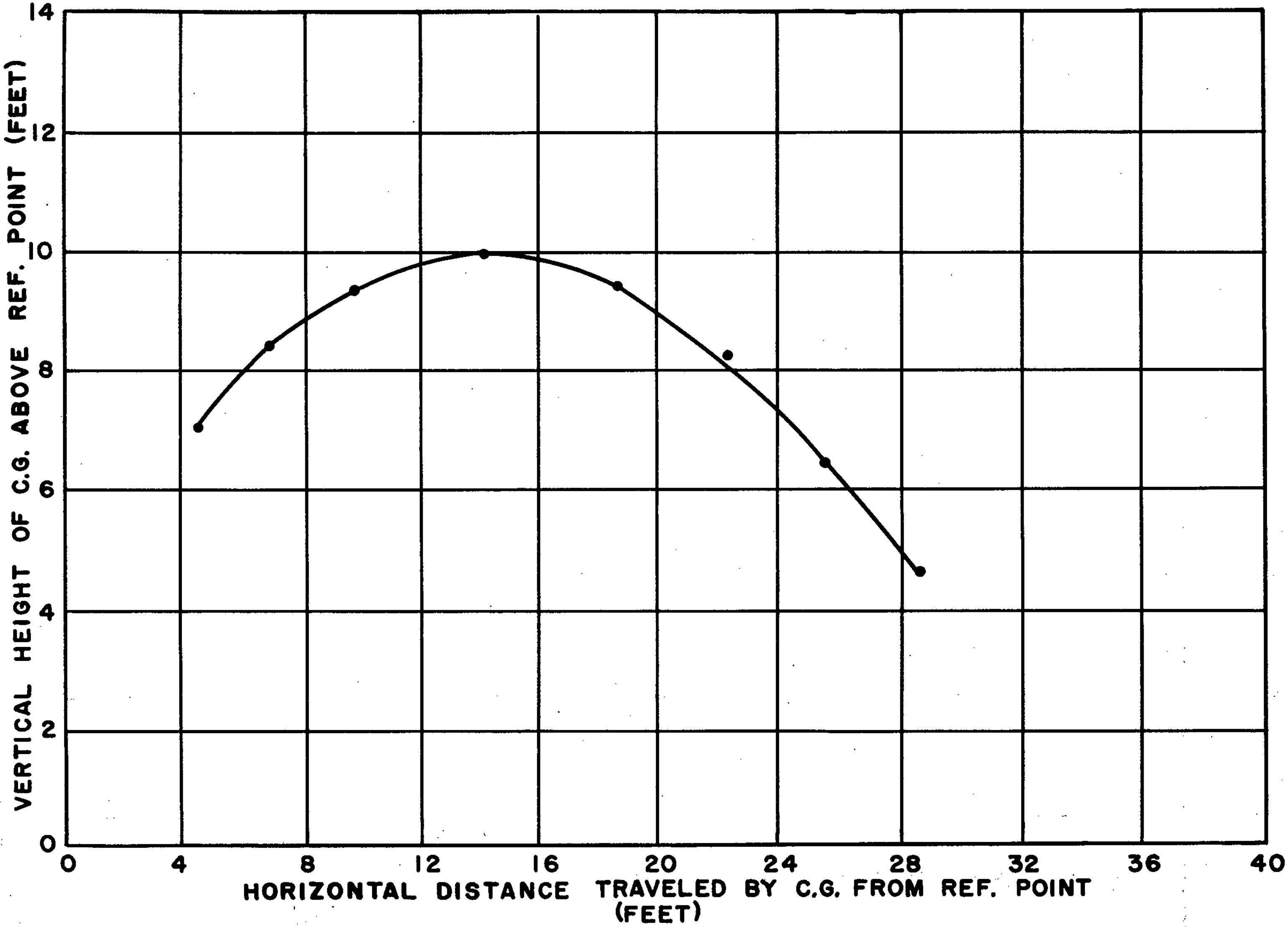
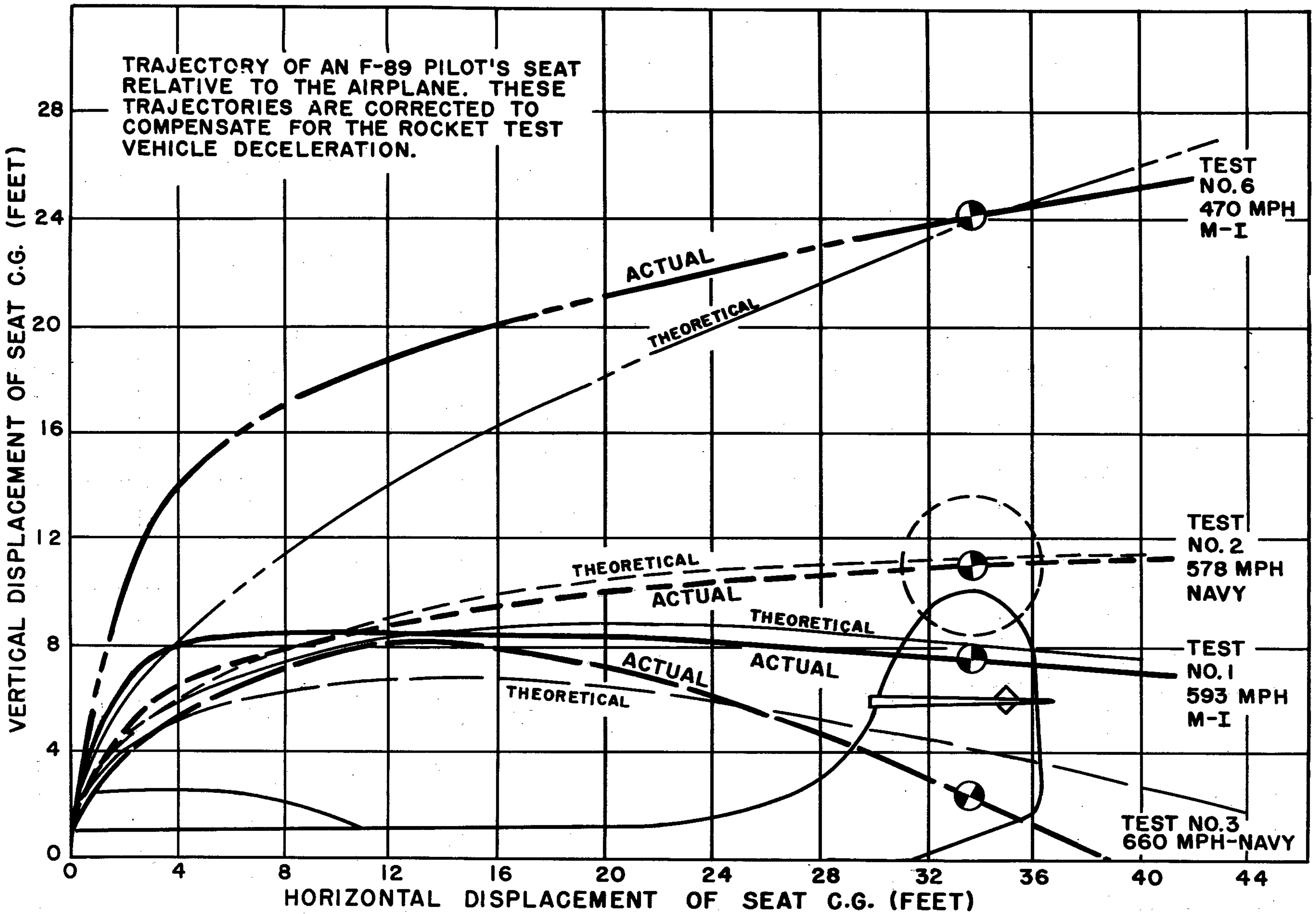


FIGURE 28. TEST I, TRAJECTORY OF C.G. RELATIVE TO REFERENCE POINT.



"O" IS THE POSITION OF THE C.G. OF THE PILOT-SEAT CONFIGURATION AS MOUNTED IN THE AIRPLANE.

FIGURE 29. EJECTION SEAT TESTS, 10,000 FOOT FREE AIR TEST FACILITY TRACK, EDWARDS AIR FORCE BASE.

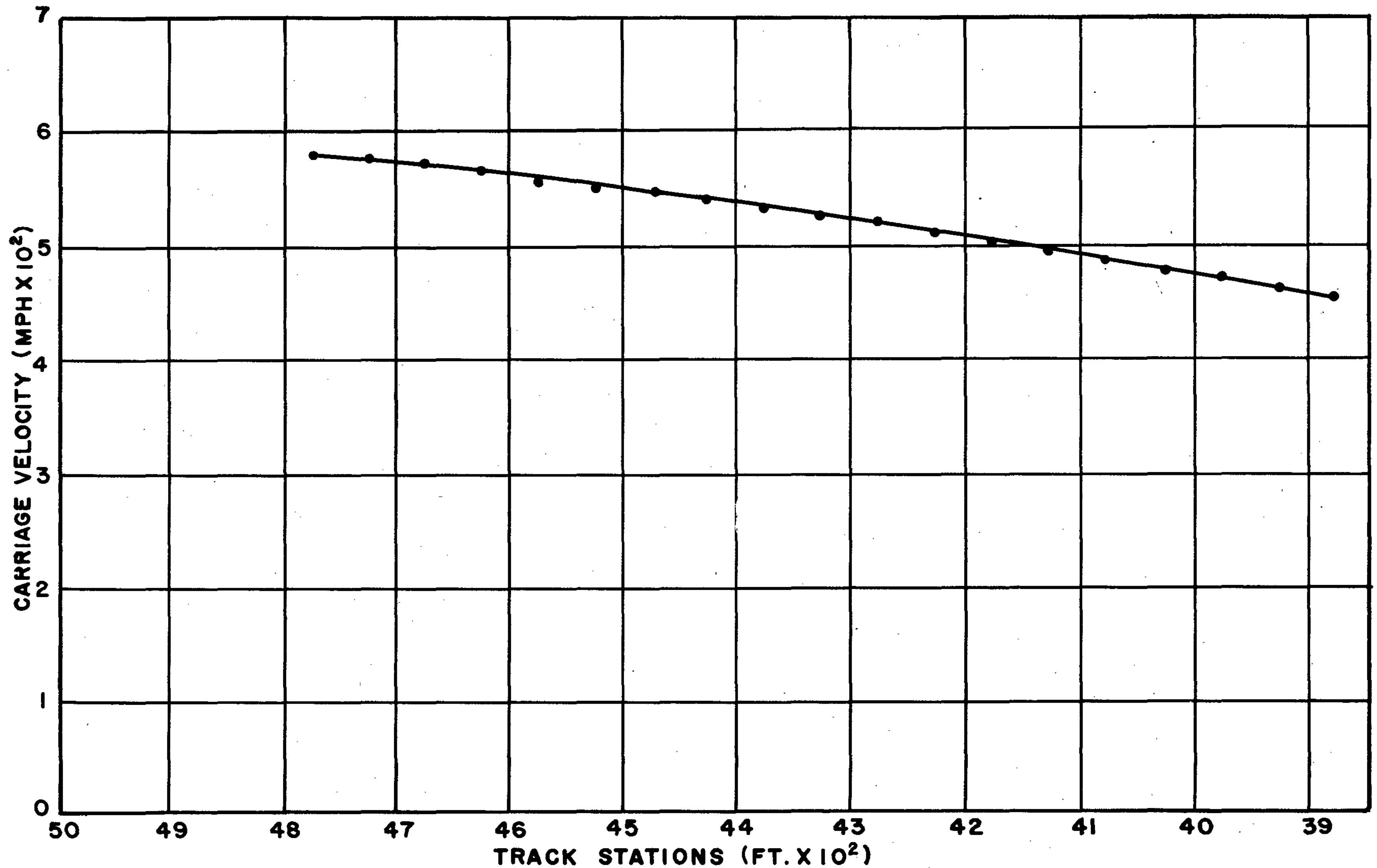


FIGURE 30. TEST 2, CARRIAGE VELOCITY VS. TRACK STATIONS.

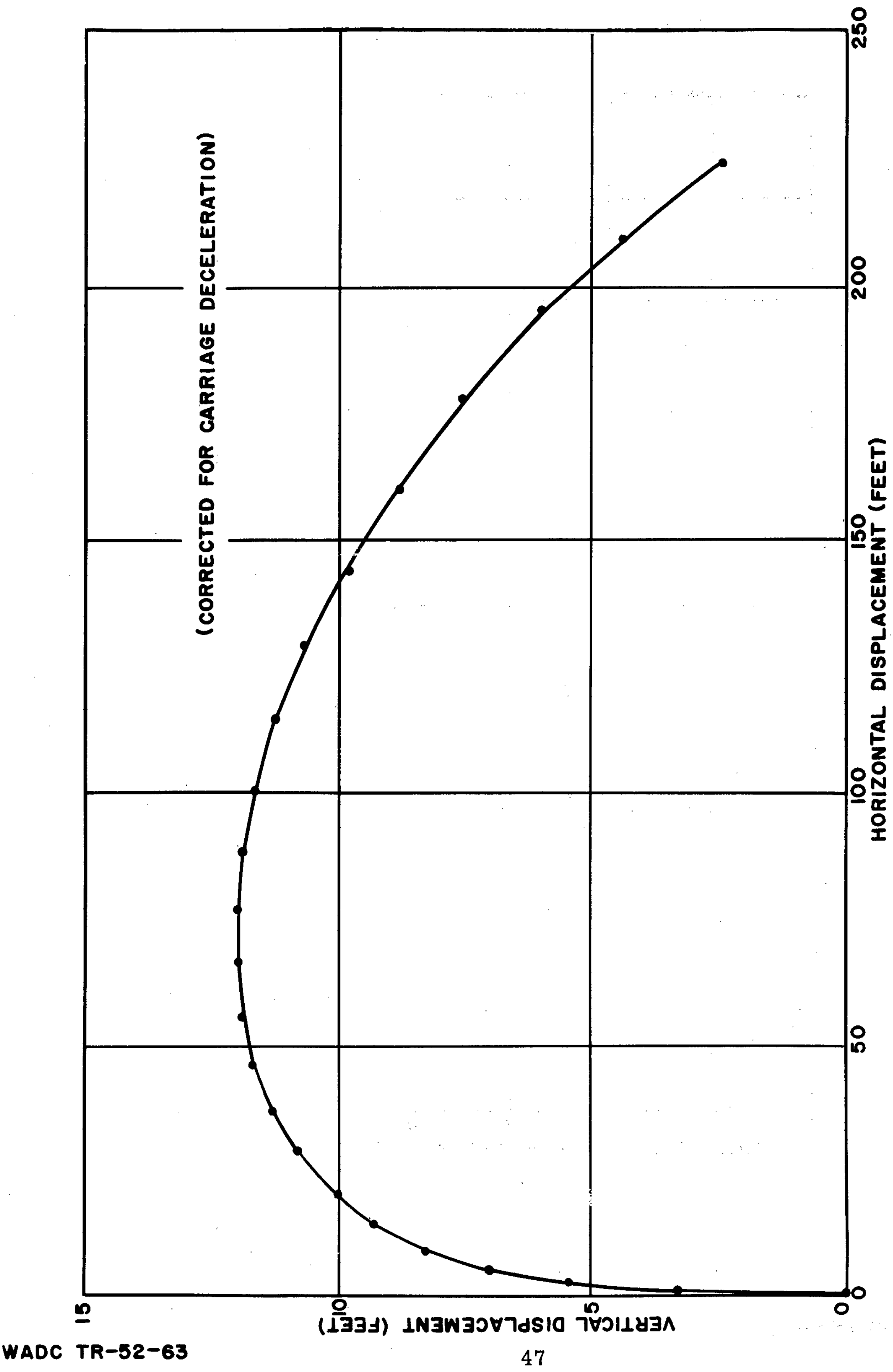


FIGURE 31. TEST 2, TRAJECTORY OF DUMMY RELATIVE TO TEST CARRIAGE.

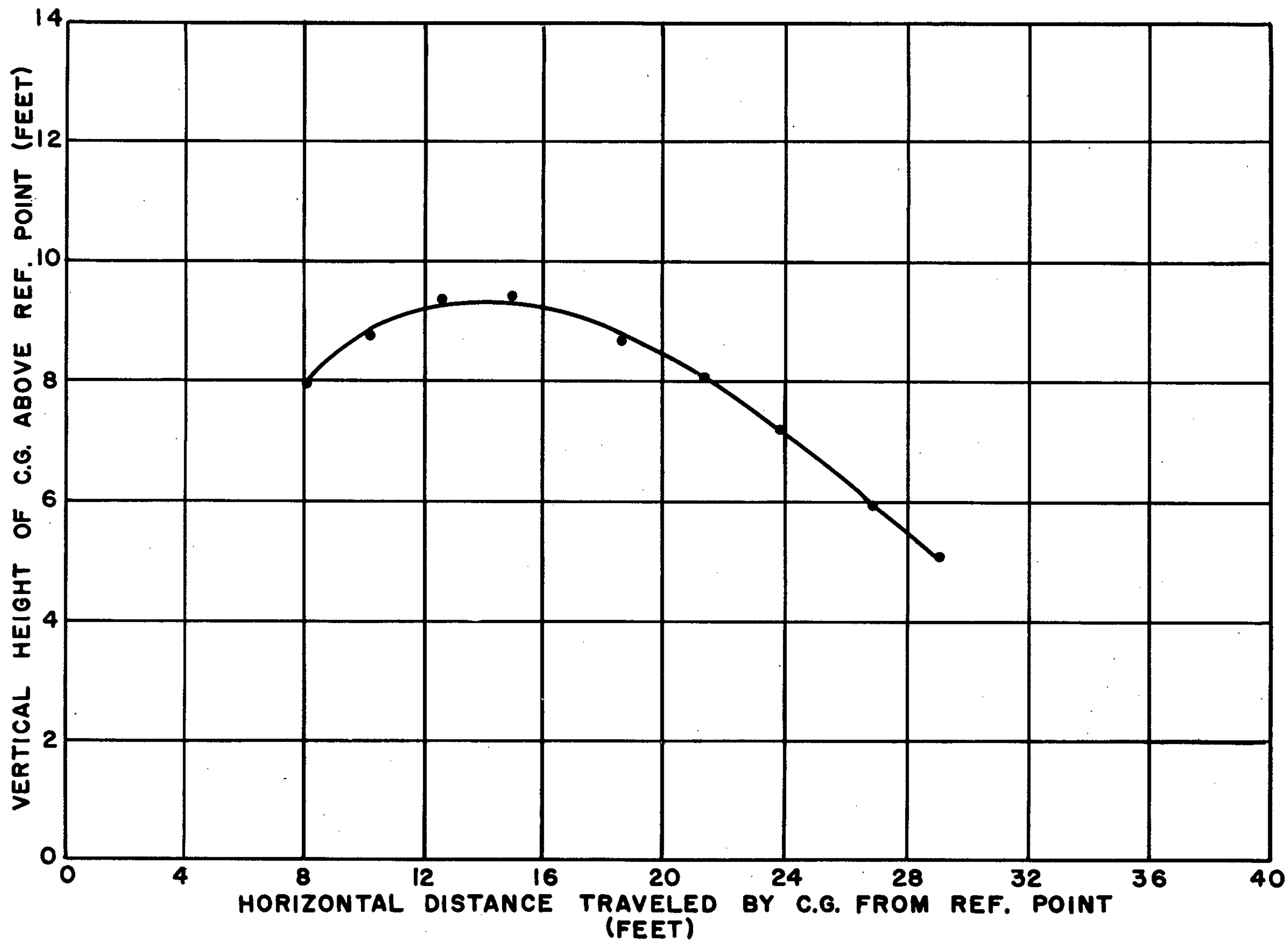


FIGURE 32. TEST 2, TRAJECTORY OF C.G. RELATIVE TO REFERENCE POINT.

FIGURE 33. TEST 2, SEAT EJECTION.

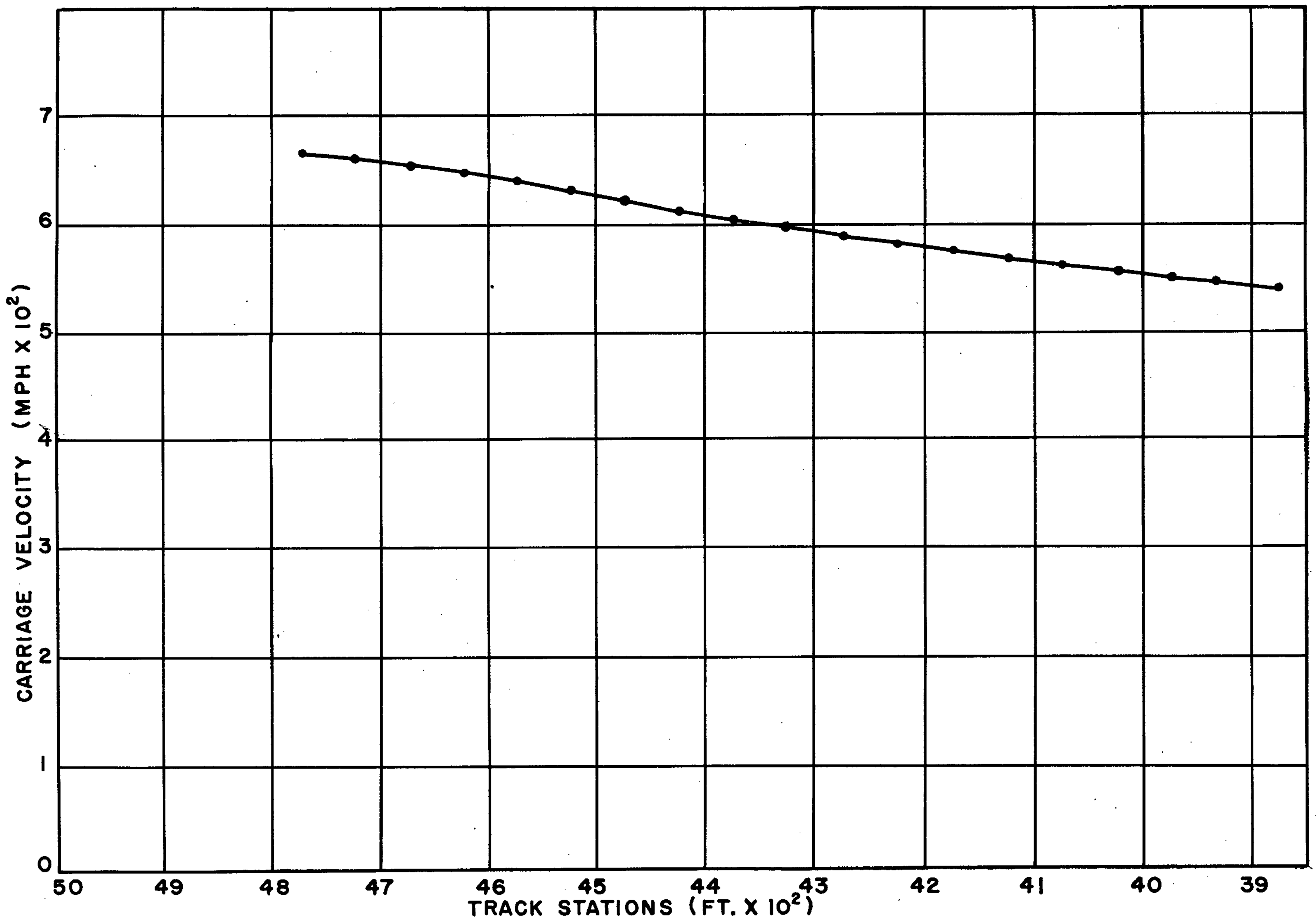


FIGURE 34. TEST 3, CARRIAGE VELOCITY VS. TRACK STATIONS.

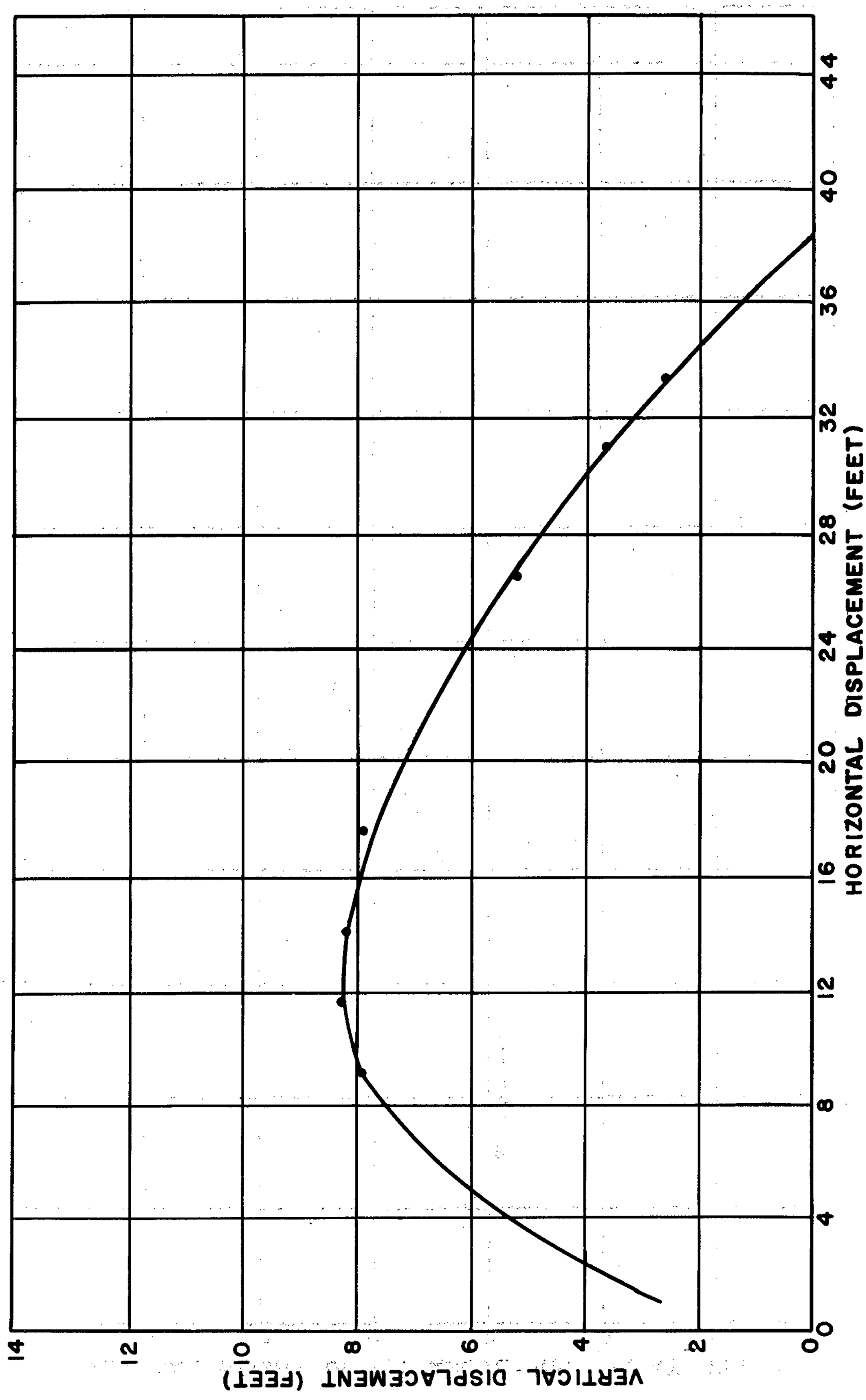


FIGURE 35. TEST 3, TRAJECTORY OF DUMMY RELATIVE TO TEST CARRIAGE.

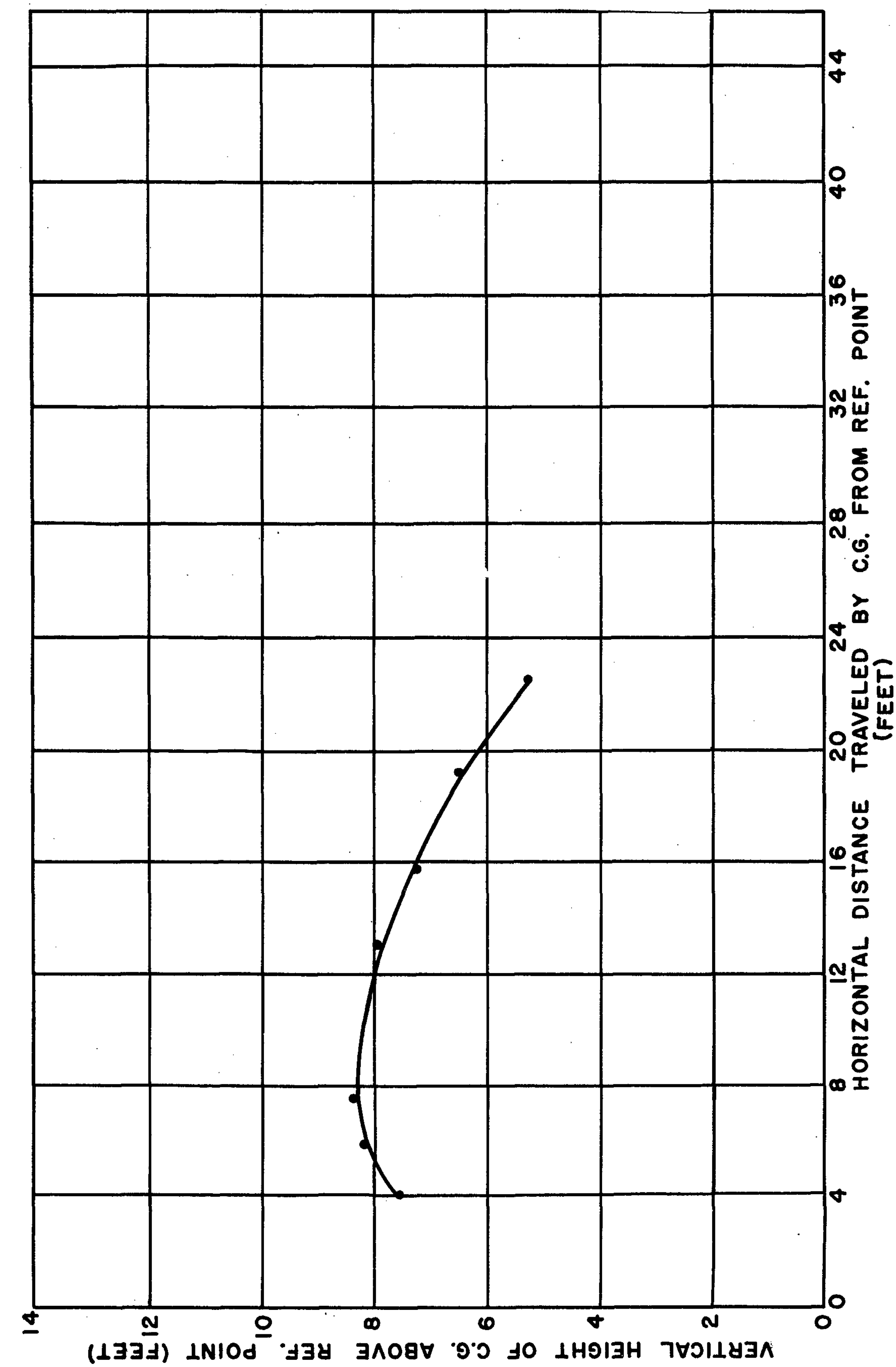


FIGURE 36. TEST 3, TRAJECTORY OF C.G. RELATIVE TO REFERENCE POINT.

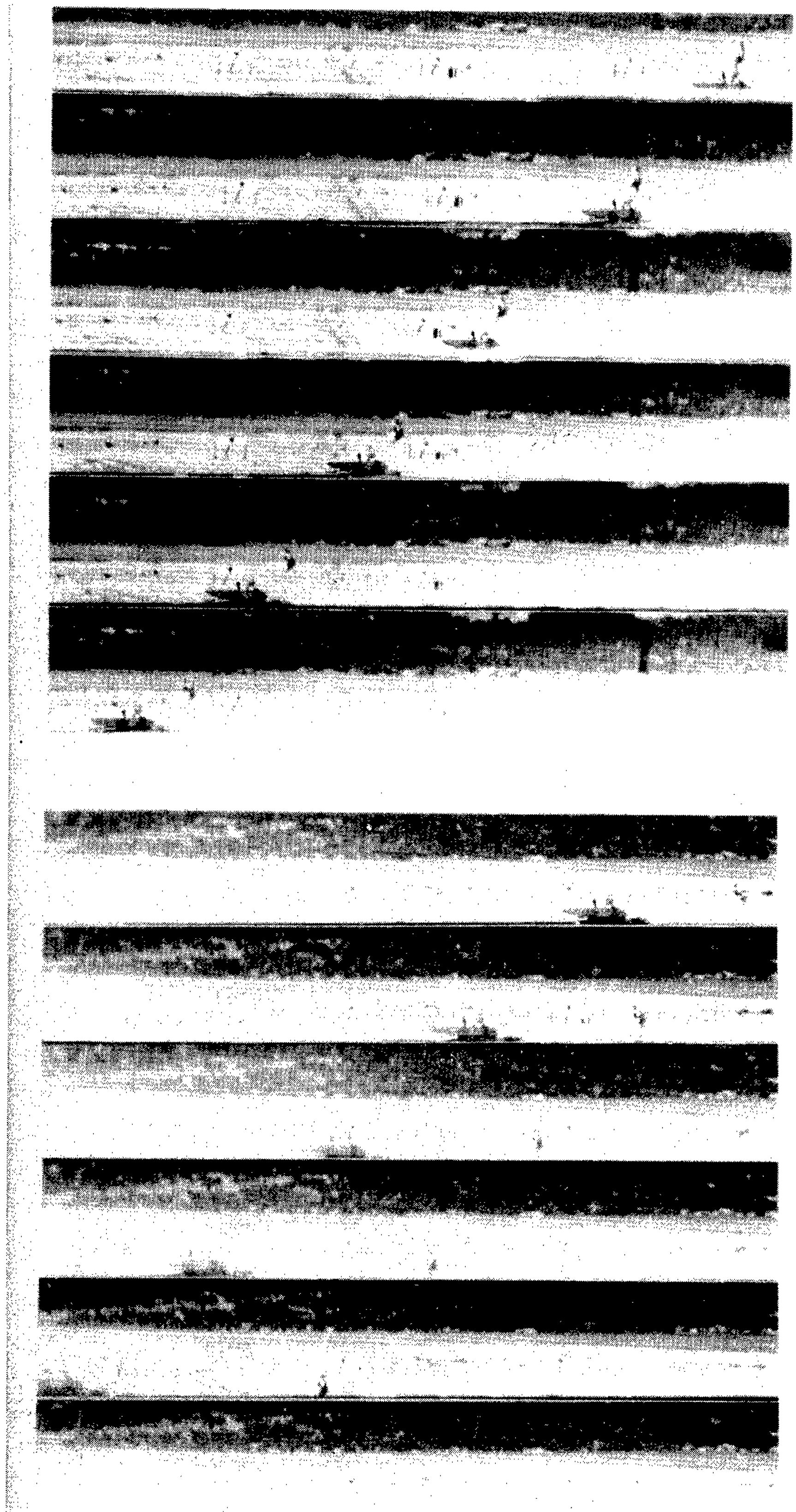


FIGURE 37. FILM STRIP, TEST 3.

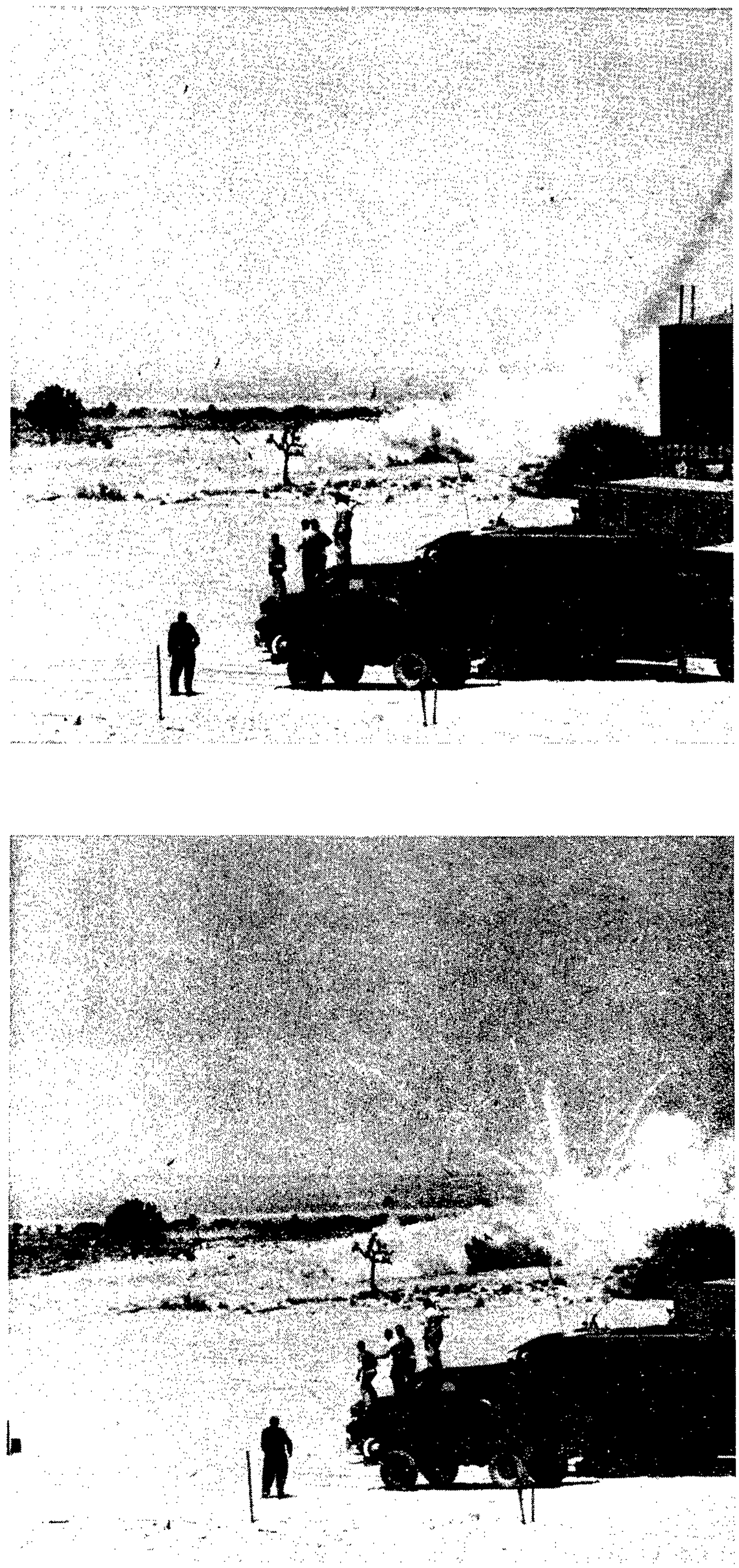


FIGURE 38. TEST 4 RESULT.

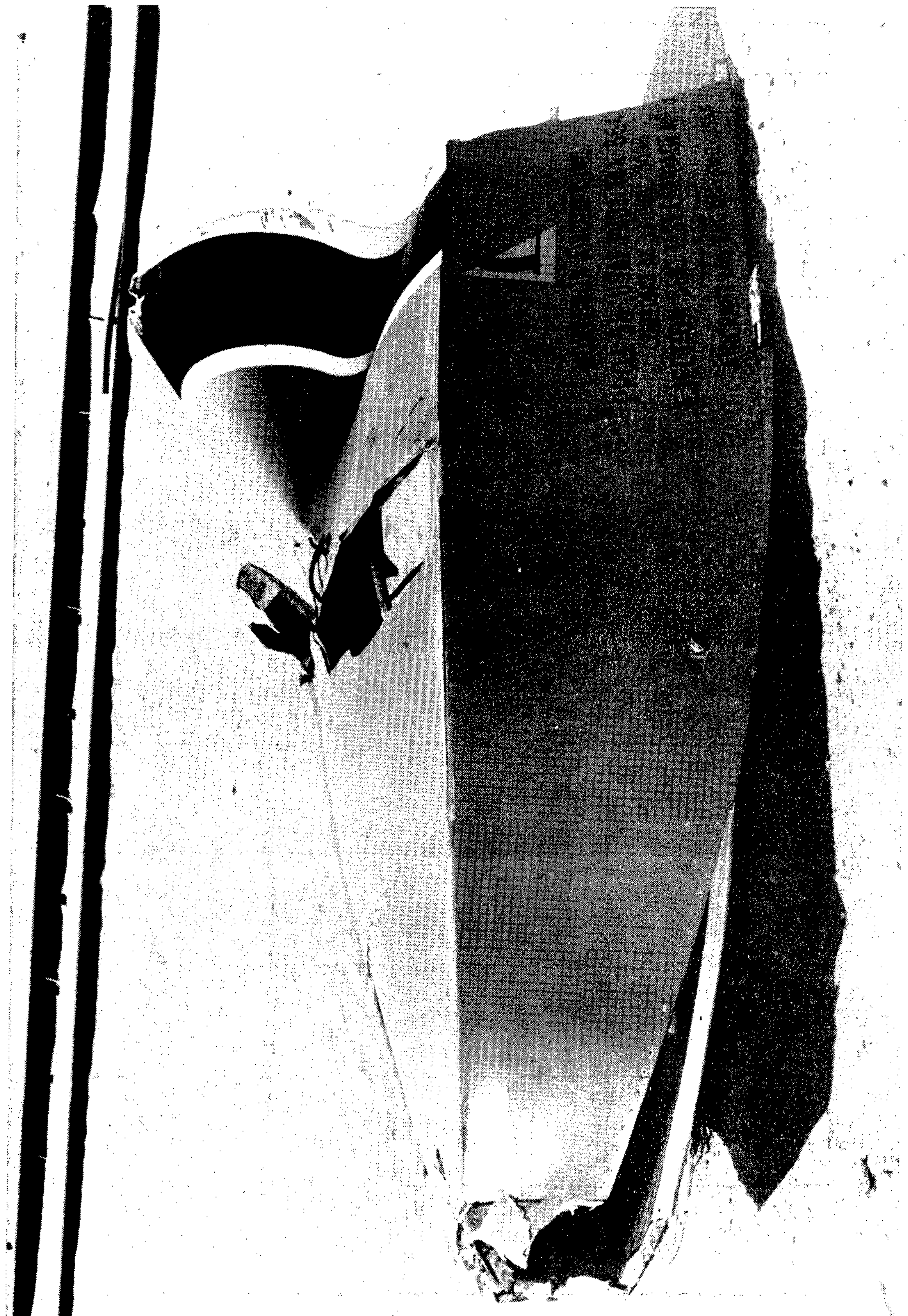


FIGURE 39. TEST 5 RESULT.

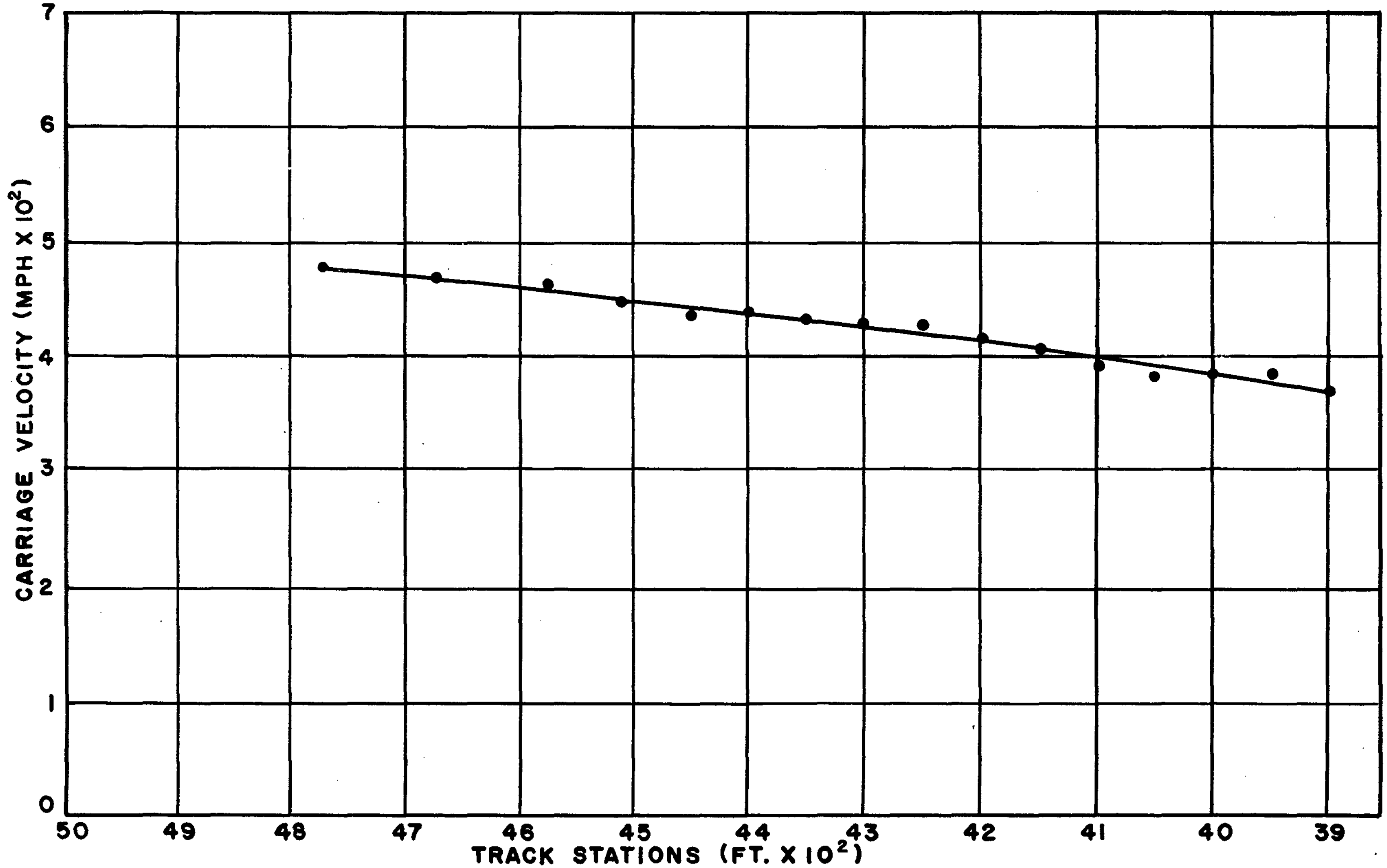


FIGURE 40. TEST 6, CARRIAGE VELOCITY VS. TRACK STATIONS.

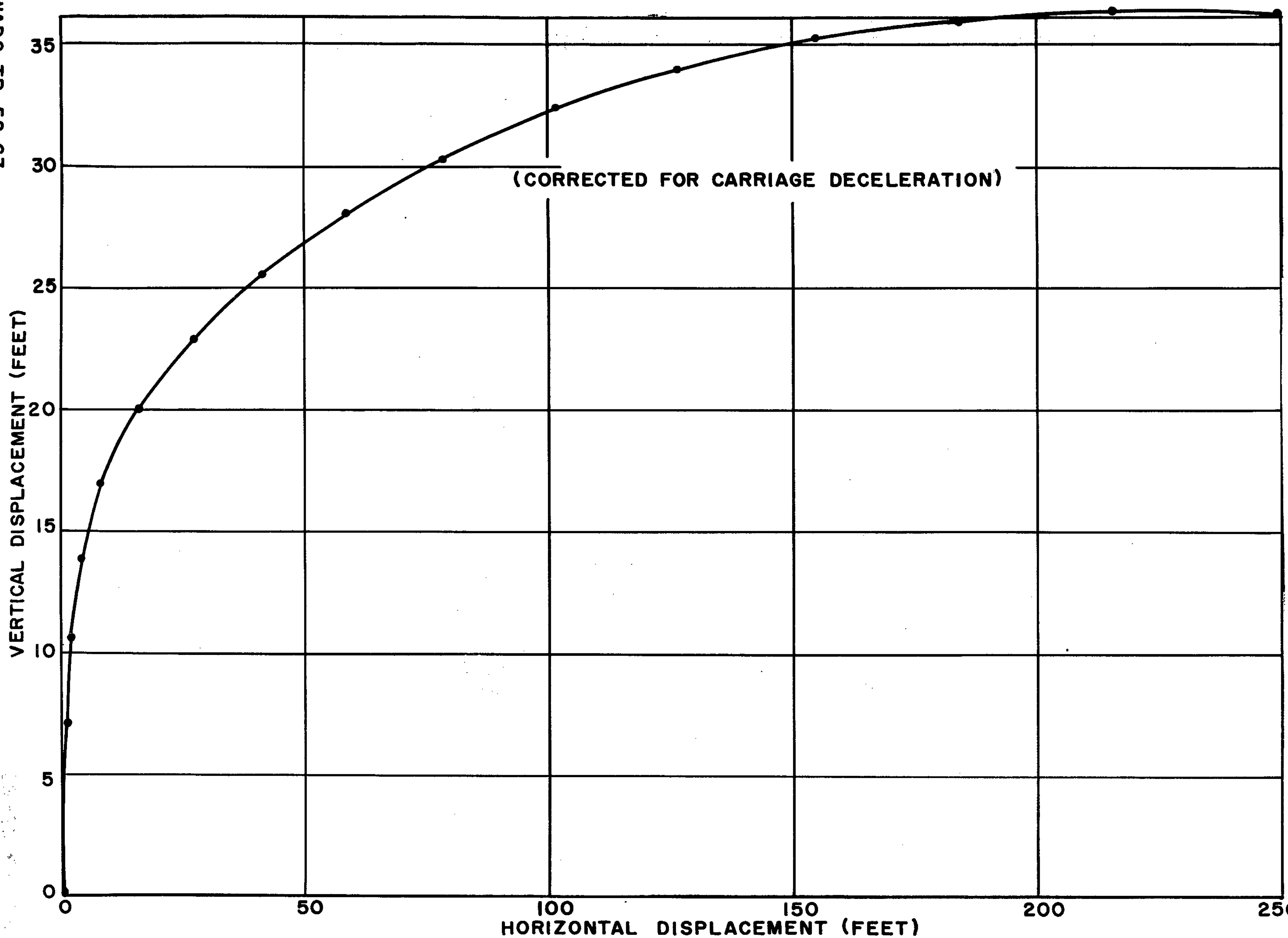


FIGURE 41. TEST 6, TRAJECTORY OF DUMMY RELATIVE TO TEST CARRIAGE.

FIGURE 42. TEST 6, TEST CARRIAGE AFTER HAVING LEFT TRACKS.

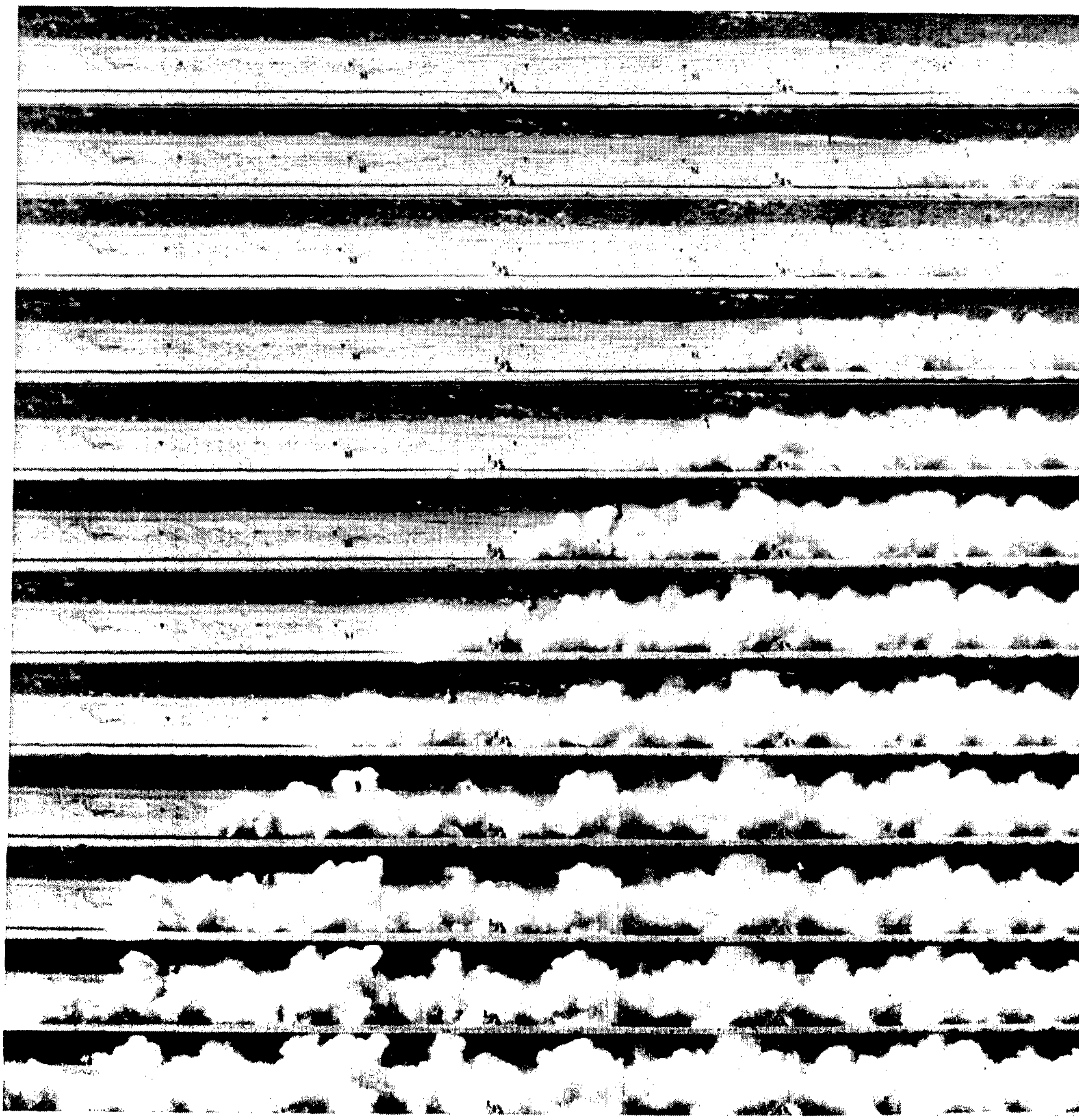


FIGURE 43. TEST 7, FILM STRIP.

REFERENCES

1. Hoerner, S. F., Trajectory and Clearance of Ejection Seats. USAF Technical Report 6350. Air Materiel Command, Wright-Patterson Air Force Base, Ohio, March 1951.

2. Carroll, Hill, and Santi, Pilot Ejection Flight Tests Conducted With A TF-80C Airplane at Muroc and Hamilton Air Force Bases. USAF Memorandum Report MCREXA7-45341-4-1. Air Materiel Command, Wright-Patterson Air Force Base, Ohio, August 1949.

3. Hecht, K. F., Pilot Ejection Flight Tests Conducted With A T-33 Airplane at Edwards Air Force Base. USAF Memorandum Report MCREXA7-45341-4-8. Air Materiel Command, Wright-Patterson Air Force Base, Ohio, March 1951.

APPENDIX I

Summation of Tests 1 through 7 include:

1. Test Configuration
2. Rocket Configuration
3. Center of Gravity
4. Instrumentation
5. Photographic Coverage
6. Rocket Carriage Performance
7. Rocket Performance
8. Remarks

DATE: 5 MAY 1950 HOUR: 1240 AMBIENT TEMPERATURE:

TEST CONFIGURATION

Weight of Ejected Mass: 324.00 Lb.

1. Standard F-89 Pilot's Seat.
2. Anthropomorphic Dummy minus hands and feet; Aero Med aluminum head with pressure pick-up; modified P-1 helmet and visor; oxygen mask.
3. Telemeter
4. B-14 Lap Belt; B-15 Shoulder Harness.
5. C-2 Emergency Kit (mock-up).
6. Seven-inch Back Type Chute (mock-up).
7. USAF M-1 Personnel Catapult, Lot No. PA-1-4; No. 290.
8. Ejection Rails as mounted in F-89.

Desired Ejection Velocity:	575 MPH
Actual Ejection Velocity:	593 MPH
Maximum Carriage Velocity:	593 MPH
Catapult Condition:	
Maximum Vertical Height of cg:	9.90 ft.
Clearance (TF80):	1.70 ft.
Catapult Velocity (Photographic):	Not Obtainable
Catapult Velocity (Instrumentation):	

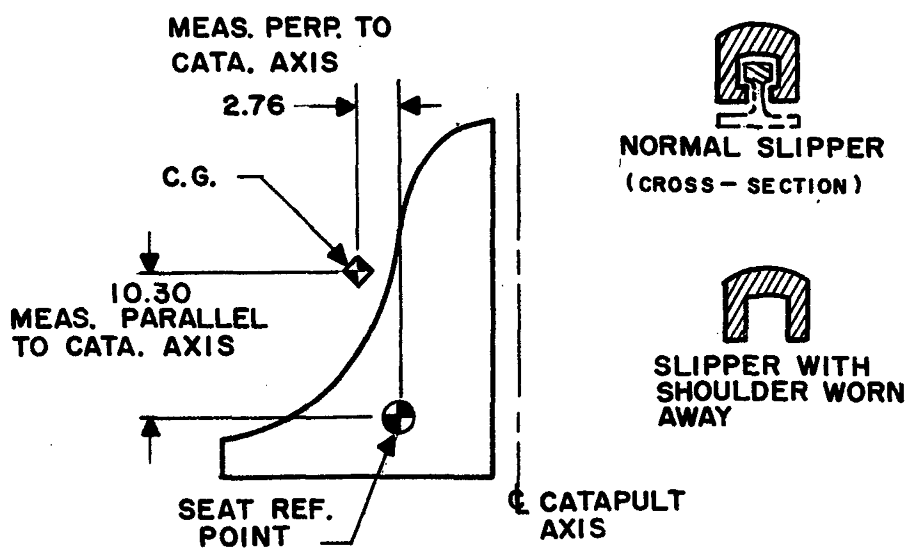
INSTRUMENTATION

4 Telemeter Channels; Chest Cavity of Dummy.

1. Normal 2. Longitudinal 3. Angular 4. Pressure Pick-up from Head

PHOTOGRAPHIC COVERAGE

2-16mm Eastman (15 ft. Tower) 3-35mm Fastax (30 ft. Tower)
1-Ribbon Frame (30 ft. Tower) 1-16mm, 128 fps Super Speed (cart)
2-16mm Eastman (Adjacent to Track - Aero Med)



C.G. AND REF. POINT LOCATION

TEST NO. 1

TEMPERATURE: 85°F WIND: 5 MPH WSW ALTITUDE: 2296.149 FT

ROCKET CARRIAGE

Weight at Fire: 2748.93 Lb

Start:	Station 57.00	Actual Eject:	Station 48.00
Tripper:	" 49.40	2.2KS Tripper:	" 06.00
Eject:	" 47.00	HVAR Tripper:	" 06.00

d aluminum
or; oxygen

ROCKET PERFORMANCE

All T10E1 rockets ignited and fired normally.
2.2KS rocket did not ignite (not triggered - torn loose from mountings; severed firing wires).
HVAR rockets broke loose from carriage as it broke up and they ignited and fizzled, either from impact or battery short circuit.

REMARKS

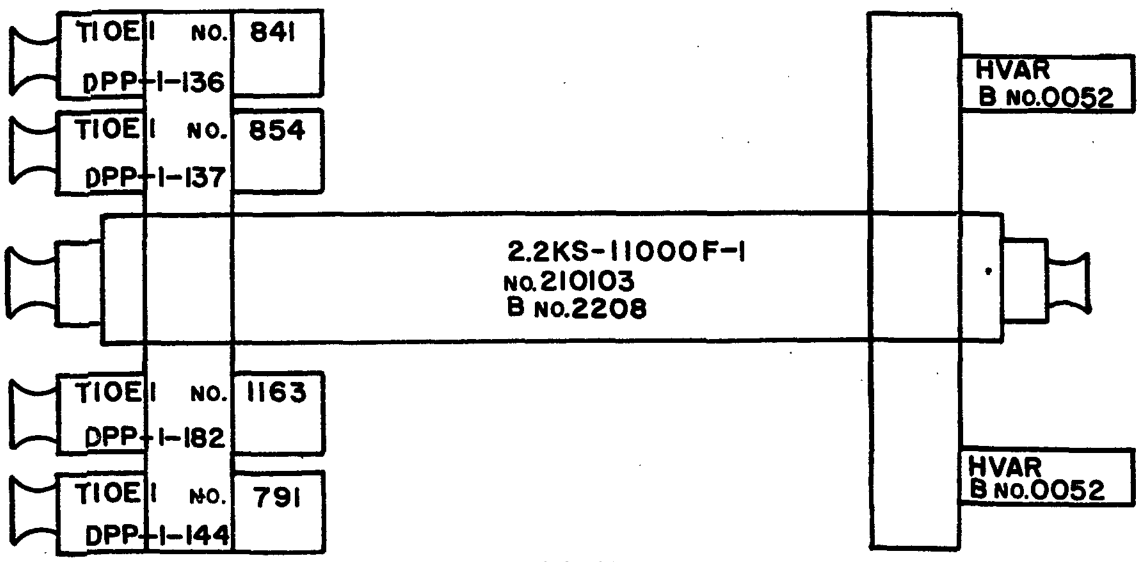
Successful run. AMC coverage complete. At approximately Station 30.00 the rocket carriage left the rails and was demolished. The retard rockets were never triggered. However, the HVARS were ignited by impact. The 2.2KS did not ignite. The combination of aerodynamic lift from the fuselage mock-up and friction caused the shoulders of the cast aluminum slippers on the front to wear away. When this occurred, the rocket carriage left the rails. New steel slippers with Stellite inserts will be fabricated by contractor. Mr. C. R. Hill (L. A. Ord. Dist.) suggested that improved method of mounting the 2.2KS rocket be used, since the 2.2KS rocket had torn loose from the center tube and was catapulted through the air.

up from Head

ower)
peed (cart)

. SLIPPER
SECTION)

ER WITH
LDER WORN



ROCKET CONFIGURATION

2

TEST NO. 2

DATE: 24 MAY 1950 HOUR: 1430 AMBIENT TEMPERATURE 83°F WI

TEST CONFIGURATION

Weight of Ejected Mass: 324.00 Lb.

1. Standard F-89 Pilot's Seat; modified to accommodate Navy Catapult.
2. Anthropomorphic Dummy minus hands and feet.
3. Telemeter.
4. B-14 Lap Belt; B-15 Shoulder Harness.
5. C-2 Emergency Kit (mock-up).
6. Seven-inch Back Type Chute (mock-up).
7. NAMC MK I, Type I Personnel Catapult
8. Ejection Rails permitting fully guided catapult stroke.

Desired Ejection Velocity:	575 MPH
Actual Ejection Velocity:	578 MPH
Maximum Carriage Velocity:	593 MPH
Catapult Condition:	
Maximum Vertical Height of cg:	9.40 ft.
Clearance (TF-80):	1.25 ft.
Catapult Velocity (Photographic):	54 fps
Catapult Velocity (Instrumentation):	Lost Record

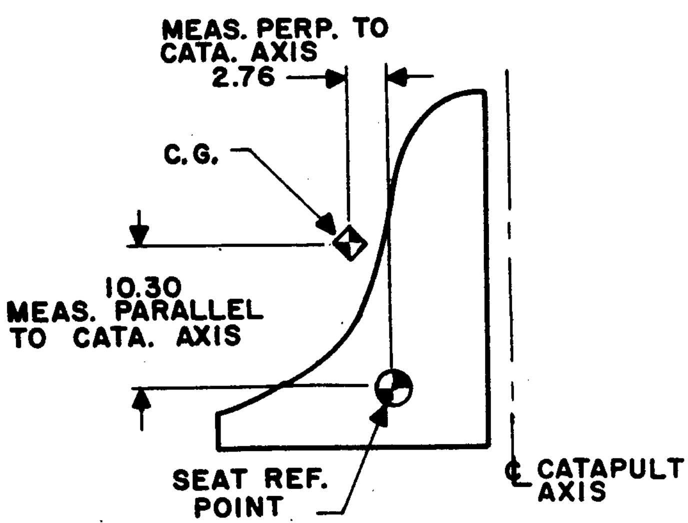
INSTRUMENTATION

3 Telemeter Channels; Chest Cavity of Dummy

1. Normal 2. Longitudinal 3. Angular

PHOTOGRAPHIC COVERAGE

3-16 mm Eastman (15 ft. Tower-additional 1 added to pick-up - 100 to 0)
4-35 mm Fastax (30 ft. Tower-additional 1 added to pick-up - 1100 to 1500)
1-Ribbon Frame (30 ft. Tower-Clutch went out at start of run)
1-16 mm 128 fps Super Speed (cart). 1-35 mm Eyemo
1-K-24. 1-35mm Akley. 1-Base Still Photo
1-GSAP (Rumbleseat-added to possibly pick up trajectory of seat after separation; however, seat appeared in only 15 frames; image blurred)

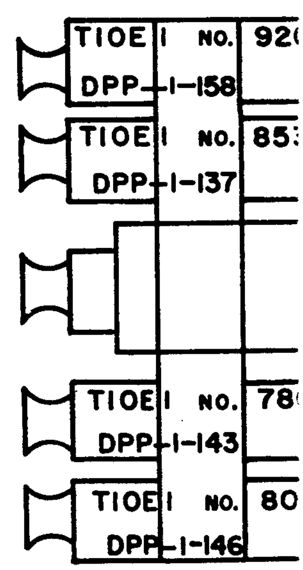


C.G. AND REF. POINT LOCATION

Start: Sta
Tripper:
Eject:

All T10E1 rock
2.2KS rocket ig
HVAR rockets

Successful run,
motor of the re
No record was
after the rocke
sooner and so
the carriage su
50 feet short of
no evidence of
additional clam
HVAR nozzles
inserted in thei
banging against



' NO. 2

RE 83°F WIND: 10 MPH WSW ALTITUDE: 2296.149 FT

ROCKET CARRIAGE.
Weight at Fire: 2760.00 Lb

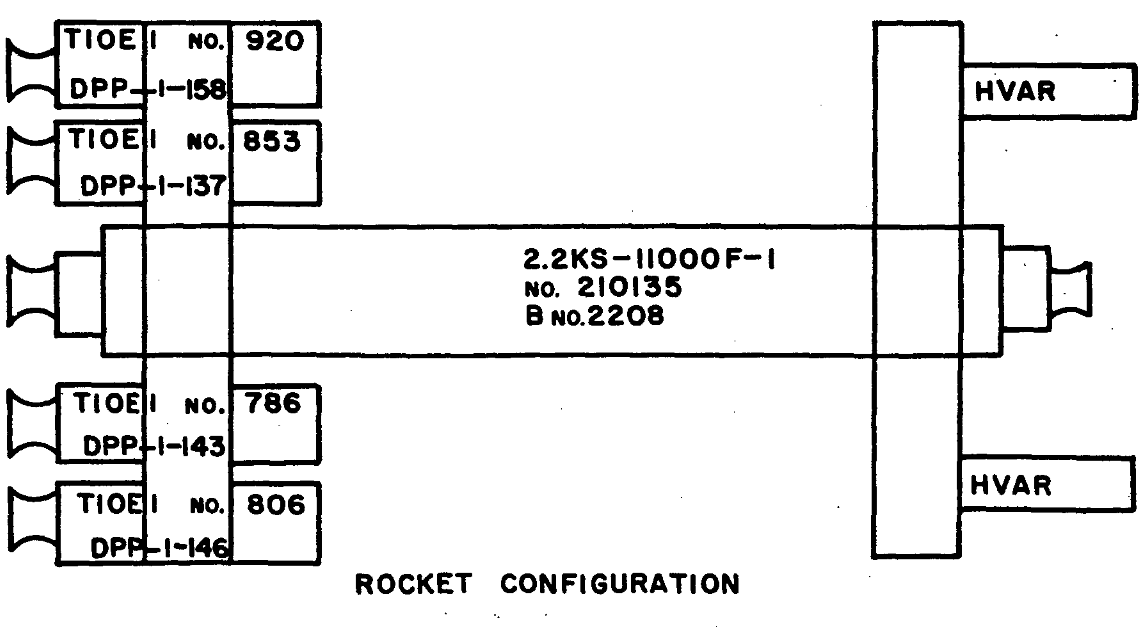
Start:	Station 57.00	Actual Eject:	Station 47.00
Tripper:	" 49.00	2.2KS Tripper:	" 36.00
Eject:	" 47.00	HVAR Tripper:	" 06.00

ROCKET PERFORMANCE

All T10E1 rockets ignited and fired normally.
2.2KS rocket ignited and fired normally.
HVAR rockets not triggered.

REMARKS

Successful run. AMC photographic coverage satisfactory. The drive motor of the recording oscillograph failed to rotate the drum during run. No record was obtained. The 2.2KS rocket was triggered immediately after the rocket carriage left the photo area to slow down the carriage sooner and so reduce wear on the slippers. The 2.2KS rocket reduced the carriage successfully. The carriage stopped at Station 06.50; 50 feet short of the HVAR Tripper. The new Stellite slippers showed no evidence of wear. The 2.2KS rocket was mounted securely with two additional clamps. Mr. C.R.Hill (L.A.Ord.Dist.) suggested that the HVAR nozzles be covered with a diaphragm and that wooden plugs be inserted in their aft ends to prevent the propellant from shifting and banging against the mounts. Rocket carriage was recovered.



ROCKET CONFIGURATION

2

DATE: 1 JUNE 1950 HOUR: 1245 AMBIENT TEMPERAT

TEST CONFIGURATION

Weight of Ejected Mass: 324.00 Lb.

1. Standard F-89 Pilot's Seat; modified to accommodate Navy Catapult.
2. Anthropomorphic Dummy minus hands and feet.
3. Telemeter.
4. B-14 Lap Belt; B-15 Shoulder Harness.
5. C-2 Emergency Kit (mock-up).
6. Seven-inch Back Type Chute (mock-up).
7. NAMC MK I, Type I Personnel Catapult.
8. Ejection Rails permitting fully guided catapult stroke.

Desired Ejection Velocity:	650 MPH
Actual Ejection Velocity:	665 MPH
Maximum Carriage Velocity:	
Catapult Condition:	
Maximum Vertical Height of cg:	8.30 ft.
Clearance (TF-80):	0.90 ft.
Catapult Velocity (Photographic):	52.5 fps
Catapult Velocity (Instrumentation):	

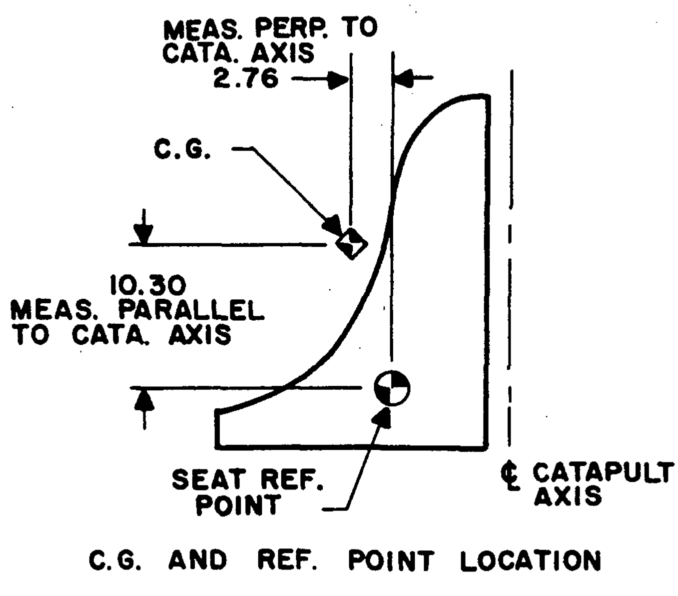
INSTRUMENTATION

3 Telemeter Channels; Chest Cavity of Dummy

1. Normal 2. Longitudinal 3. Rotational

PHOTOGRAPHIC COVERAGE

1-35 mm Akley. 1-35 mm Eyemo. 1-K-24. 1-Base Still Photo.
3-16 mm Eastman (15 ft. Tower). 4-35 mm Fastax (30 ft. Tower).
1-16 mm 128 fps Super Speed (cart). 1-Ribbon Frame(30 ft. Tower).
1-GSAP (Rumbleseat-this camera removed after run. Image on only six frames and blurred. Camera removed).



C.G. AND REF. POINT LOCATION

TEST NO. 3

BIENT TEMPERATURE: 100°F WIND: 5 MPH WNW ALTITUDE: 2296.149 FT

ROCKET CARRIAGE

Weight at Fire: 3022.70 Lb

te Navy Catapult.

Start:	Station	59.00	Actual Eject:	Station	47.50
Tripper:	"	50.00	2.2KS Tripper:	"	36.00
Eject:	"	47.00	HVAR Tripper:	"	10.00

ROCKET PERFORMANCE

All T10E1 rockets ignited and fired normally.
2.2KS rocket ignited and fired normally.
The 2 HVAR rockets ignited and fired normally.

e.

REMARKS

Successful run. AMC coverage complete. Rocket carriage and rockets performed satisfactorily. Rocket carriage recovered.

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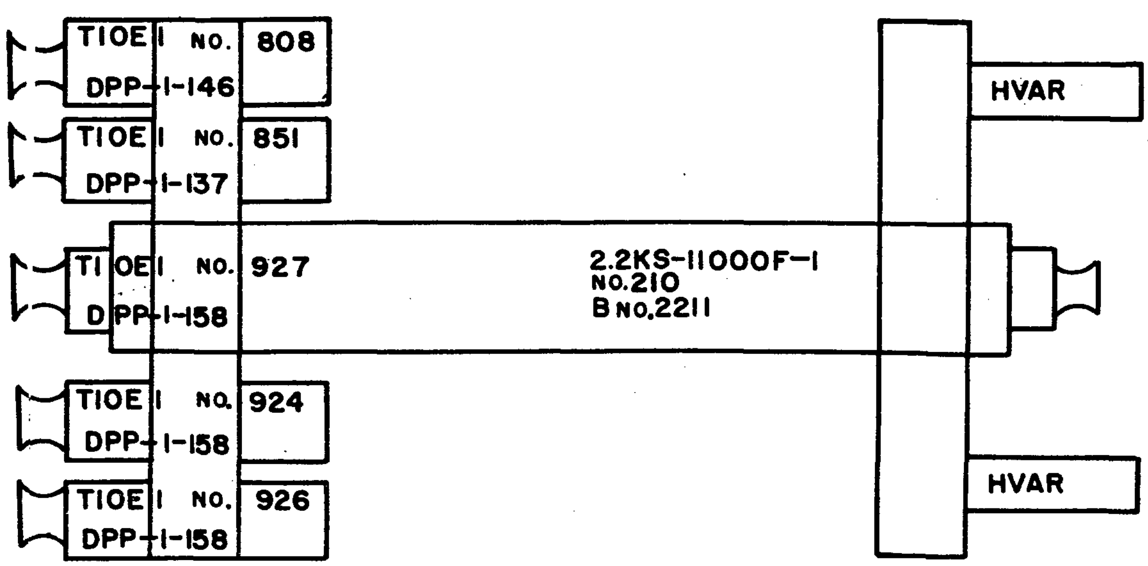


.T

ROCKET CONFIGURATION

2

TEST NO. 4

DATE: 3 JUNE 1950 HOUR: 1440 AMBIENT TEMPERATURE: 94 1/2°F

TEST CONFIGURATION

Weight of Ejected Mass: 324.00 Lb.

1. Standard F-89 Pilot's Seat; modified to accommodate NAMC Catapult.
2. Anthropomorphic Dummy minus hands, feet and arms. Arms were removed and ballast added to bottom of seat of equal weight in order to lower the cg of the configuration 1 1/4 inches.
3. Telemeter.
4. B-14 Lap Belt; B-15 Shoulder Harness.
5. C-2 Emergency Kit (mock-up).
6. Seven-inch Back Type Chute (mock-up).
7. NAMC MK I, Type I Personnel Catapult.
8. Ejection Rails permitting fully guided stroke of catapult.

Desired Ejection Velocity:	650 MPH
Actual Ejection Velocity:	--
Maximum Carriage Velocity:	--
Catapult Condition:	--
Maximum Vertical Height of cg:	--
Clearance (TF-80):	--
Catapult Velocity (Photographic):	--
Catapult Velocity (Instrumentation):	--

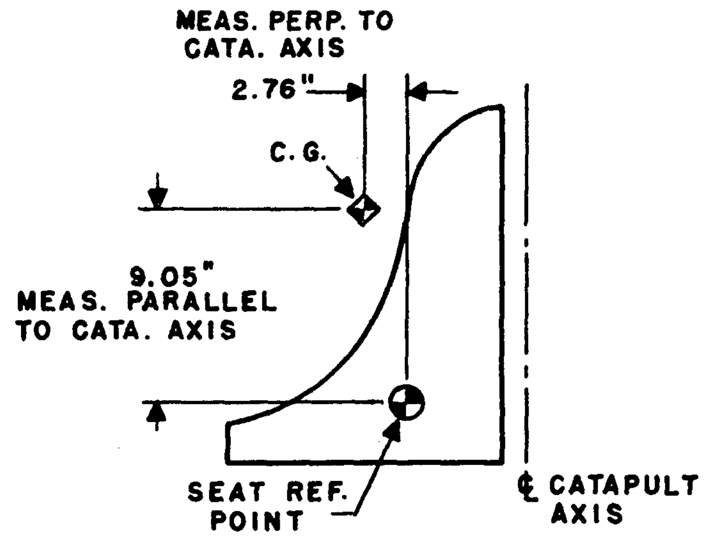
INSTRUMENTATION

3 Telemeter Channels; Chest Cavity of Dummy

1. Normal 2. Longitudinal 3. Angular

PHOTOGRAPHIC COVERAGE

3-16mm Eastman (15 ft. Tower)	1-K-24
4-35mm Fastax (30 ft. Tower)	1-Base Still Photo
1-Ribbon Frame (30 ft. Tower)	1-35mm Eyemo
1-16mm 128 fps Super Speed (cart)	1-35mm Akley



C.G. AND REF. POINT LOCATION

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Eject:

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along the track
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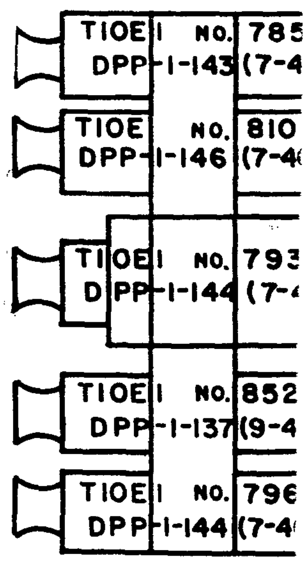


NO. 4

E: 94 1/2°F WIND: 5 MPH AND GUSTY ALTITUDE: 2296.149 FT

ROCKET CARRIAGE

Weight at Fire: 3022.70 Lb

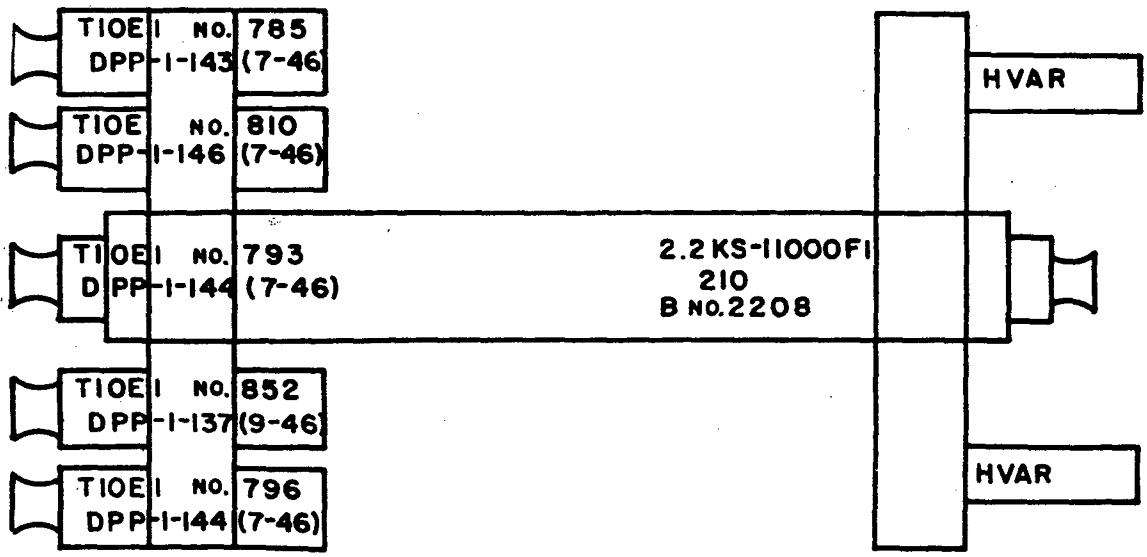
Start:	Station 59.00	Actual Eject:	Station --
Tripper:	" 49.40	2.2KS Tripper:	" 36.00
Eject:	" 47.00	HVAR Tripper:	" 10.00

ROCKET PERFORMANCE

Approximately 0.30 seconds after ignition, T10E1 rocket units numbers 810 and 852 exploded. It is believed that unit 810 exploded first and in turn caused unit 785 to rupture and explode. Shortly after unit 810 exploded, it was followed by unit 852. The explosion of these three units broke up the rocket carriage. When this occurred, unit 796 propelled itself through the air and landed approximately 475 feet along the left hand side of the track. Unit 793 (in the center tube) propelled the center tube holding the 2.2KS rocket approximately 600 feet up the center of the rails. The left hand HVAR was driven forward, end over end, along the track approximately 1200 feet (blew out the aft end). The right hand HVAR and mount propelled itself approximately one mile along the track to the rear of the starting point. The 2.2KS rocket did not ignite. Contributing causes of T10E1 failure: 1. long exposure to sun; 2. border line acceptances.

REMARKS

Unsuccessful run. Rocket carriage destroyed. No AMC data. The Base has restricted the T10E1 rockets. No personnel injuries.



ROCKET CONFIGURATION

TEST NO. 6

DATE: 7 JULY 1950 HOUR: 1550 AMBIENT TEMPERATURE: 97°F

TEST CONFIGURATION

1. Standard F-89 Pilot's Seat.
2. Anthropomorphic Dummy minus hands and feet; Aero Med aluminum head (no pressure pick-up); modified P-1 helmet, visor; oxygen mask.
3. B-14 Lap Belt; B-15 Shoulder Harness.
4. C-2 Emergency Kit (mock-up).
5. Seven-inch Back Type Chute (mock-up).
6. USAF M-1 Personnel Catapult, Lot No. PA-1-4; No. 207.
7. Ejection Rails as mounted in F-89.

Desired Ejection Velocity:	450 MPH
Actual Ejection Velocity:	470 MPH
Maximum Carriage Velocity:	478 MPH
Catapult Condition:	
Maximum Vertical Height of cg:	
Clearance (TF-80):	
Catapult Velocity (Photographic):	
Catapult Velocity (Instrumentation):	Not instrumented.

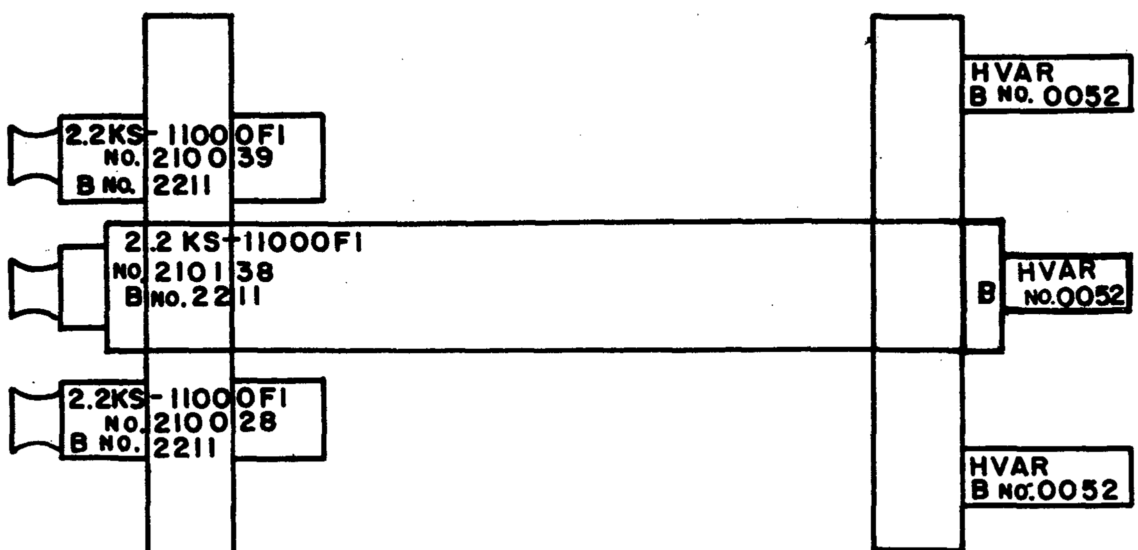
INSTRUMENTATION

4 Telemeter Channels; located on longitudinal tube of rocket carriage in same relative position as chest cavity of dummy.

1. Longitudinal 2. Vertical 3. Lateral 4. Angular

PHOTOGRAPHIC COVERAGE

3-16mm Eastman (15 ft. Tower)	1-16mm Super Speed (cart)
4-35mm Fastax (30 ft. Tower)	1-35mm Akley
1-Ribbon Frame (30 ft. Tower)	1-K-24
2-16mm Eastman (adjacent to track-Aero Med)	1-35mm Eyemo
1-16mm Eastman (adjacent to track-Armament Br.)	



ROCKET CONFIGURATION

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Eject:

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TEST NO. 6

\TURE: 97°F WIND: 5 MPH W ALTITUDE: 2296.149 FT

ROCKET CARRIAGE

Start:	Station 65.50	Actual Eject:	Station 47.00
Tripper:	" 48.00	1st HVAR Tripper:	" 36.00
Eject:	" 47.00	2nd HVAR Tripper:	" 10.00

ROCKET PERFORMANCE

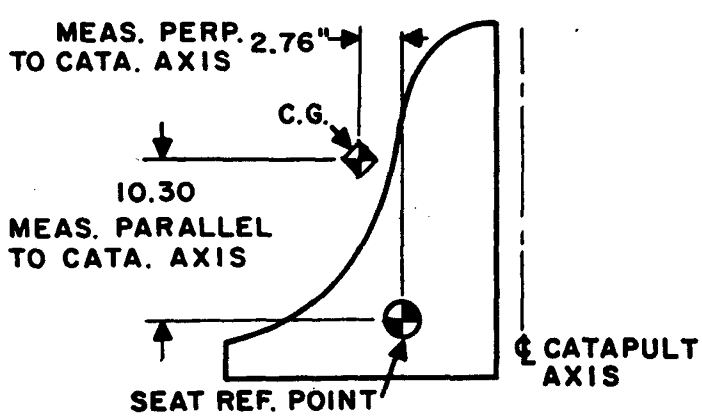
The 2.2KS accelerators ignited and fired normally except that unit 210039 exhibited some residual burning for three and one-half minutes after the rocket carriage stopped. The three HVAR retarders were ignited prematurely approximately 200 feet from the initial fire point. This reduced the retard factors on the rocket carriage to practically zero. The carriage left the track and continued for approximately 300 feet on into the desert terrain. The carriage sustained major damage and the mock-up minor and repairable damage. Since the trigger blades for the HVAR micro switches were wiped off at their respective track stations, it has been tentatively believed that the HVAR rockets were impact ignited.

REMARKS

Successful test. All AMC data obtained. This was a calibration run to compare the trajectory of this test with the trajectory of an aircraft ejection. The instrumentation also was of a calibration nature since the rocket carriage itself was instrumented and not the dummy. This was done to try to determine the cause of the "hash" on the instrumentation records. This could have been caused by the following:

1. Rocket burn-out occurring at ejection.
2. Porpoising of rocket carriage.
3. Deflections of dummy-seat system.
4. Deflections of seat-rails system.

The rocket carriage was backed off from the ejection point a distance greater than has been the custom, to allow the rocket carriage to obtain a sufficient velocity to coast through the ejection point at the desired velocity with the rockets expended (See 1. above). The ejection seemed unusually high for the velocity, and the seat tumbling was more pronounced than in the other tests.



C.G. AND REF. POINT LOCATION

TEST NO.

DATE: 13 JUNE 1950 HOUR: 1450 AMBIENT TEMPERATURE: 76°

TEST CONFIGURATION

Weight of Ejected Mass: 324.00 Lb.

1. Standard F-89 Pilot's Seat.
2. Anthropomorphic Dummy minus hands and feet; Aero Med aluminum head (no pressure pick-up); modified P-1 helmet and visor; oxygen mask.
3. Telemeter.
4. B-14 Lap Belt; B-15 Shoulder Harness.
5. C-2 Emergency Kit (mock-up).
6. Seven-inch Back Type Chute (mock-up).
7. USAF M-1 Personnel Catapult.
8. Ejection Rails as mounted in F-89.

Desired Ejection Velocity:	650 MPH
Actual Ejection Velocity:	--
Maximum Carriage Velocity:	--
Catapult Condition:	--
Maximum Vertical Height of cg:	--
Clearance (TF-80):	--
Catapult Velocity (Photographic):	--
Catapult Velocity (Instrumentation):	--

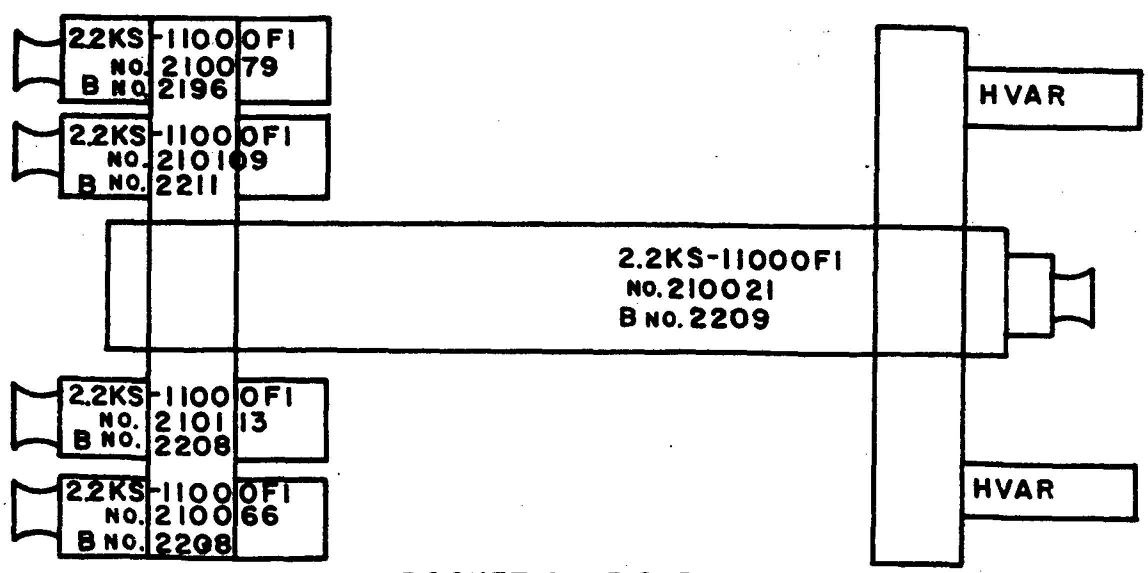
INSTRUMENTATION

3 Telemeter Channels; Chest Cavity of Dummy

1. Normal 2. Longitudinal 3. Angular

PHOTOGRAPHIC COVERAGE

3-16mm Eastman (15 ft. Tower)	1-16mm Eastman (Aero Med Coverage)
4-35mm Fastax (30 ft. Tower)	1-35mm Eyemo
1-Ribbon Frame (30 ft. Tower)	1-35mm Akley
1-16mm Super Speed (cart)	1-K-24



ROCKET CONFIGURATION

TEST NO. 5

T TEMPERATURE: 76°F   WIND: 25 MPH W   ALTITUDE: 2296.149 FT

ROCKET CARRIAGE

Weight at Fire: 2844.93 Lb

Start:	Station 62.00	Actual Eject:	Station --
Tripper:	" 49.40	2.2KS Tripper:	" 36.00
Eject:	" 47.00	HVAR Tripper:	" 10.00

Med aluminum
or; oxygen mask.

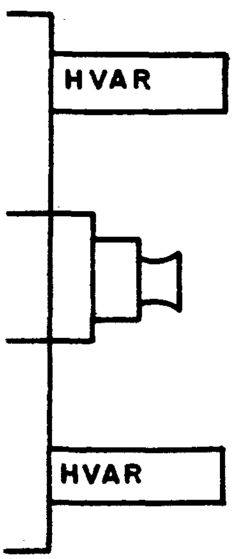
ROCKET PERFORMANCE

Approximately 1.25 seconds after ignition, the rocket carriage left the rails and was destroyed. To date (30 June 1950) the cause of the malfunction is unknown. It is believed that there were many factors which could have contributed to the accident. However, no evidence has been found that would irrevocably place the blame on any one of the following contributing factors: (Project Engineer's beliefs)

1. The high initial impulse that has been found to occur in the Aerojet 2.2KS rockets.
2. Intermittent impulses of clustered Aerojet 2.2KS rockets after ignition.
3. Structural instability of the JB-2 rocket carriage; i.e. large mass, elastic structure, no inherent damping in structure.
4. Sand - either adjacent to rails or caused by slipstream of carriage and forward slippers, which in effect sandblasted the rear slippers; possibly causing them to bind, which in turn misaligned the rocket carriage and snapped the cross-arm castings.
5. Possibility of sand piled along side of the south rail, wiping off the micro switch trigger on the left hand forward slipper, which triggered the 2.2KS retard rocket. The impact of the initial thrust burst of this rocket acting against the still-firing acceleration rockets, could have broken up the rocket carriage and blown up the accelerators.
6. Poor mounting technique used in securing the Aerojet rockets may have set up initial strains in castings or at least made it possible that the castings may have cracked when the Aerojet rockets expanded upon firing. Past experiences have indicated that a torque wrench should be employed to tighten down the mounting bolts on the castings.
7. Castings themselves are brittle and are unable to stand sudden impact loads or tension loads.
8. Method of securing the cross-arm castings to the longitudinal tube appears to be very poor. Any misalignment of the cross-arms or impacts on them could free the cross-arms from the tube.
9. The 2.2KS acceleration rockets could have blown.

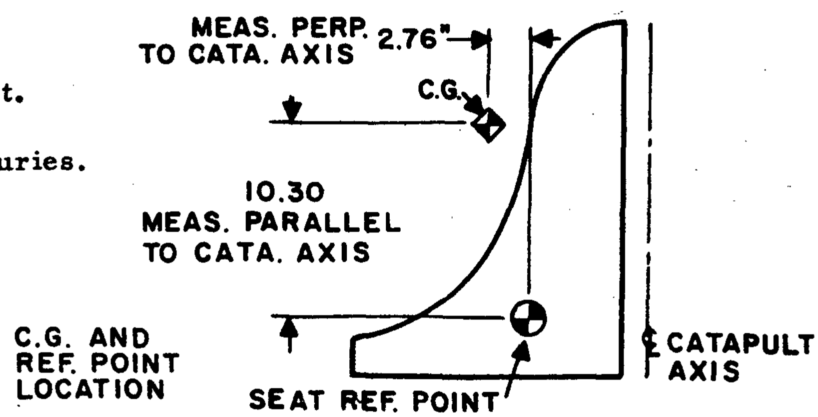
r

o Med Coverage)



REMARKS:

Unsuccessful test.
No AMC data.
No personnel injuries.



DATE: 13 JULY 1950 HOUR: 1625 AMBIENT TEMPERATURE: 107

TEST CONFIGURATION

1. Standard F-89 Pilot's Seat.
2. Anthropomorphic Dummy minus hands and feet; Aero Med aluminum head (no pressure pick-up); modified P-1 helmet, visor; oxygen mask.
3. B-14 Lap Belt; B-15 Shoulder Harness.
4. C-2 Emergency Kit (mock-up).
5. Seven-inch Back Type Chute (mock-up).
6. USAF M-1 Personnel Catapult; Lot No. PA-1-11; No. 281
7. Ejection Rails as mounted in F-89.

Desired Ejection Velocity:	650 MPH
Actual Ejection Velocity:	
Maximum Carriage Velocity:	
Catapult Condition:	
Maximum Vertical Height of cg:	
Clearance (TF-80):	
Catapult Velocity (Photographic):	
Catapult Velocity (Instrumentation):	Not instrumented.

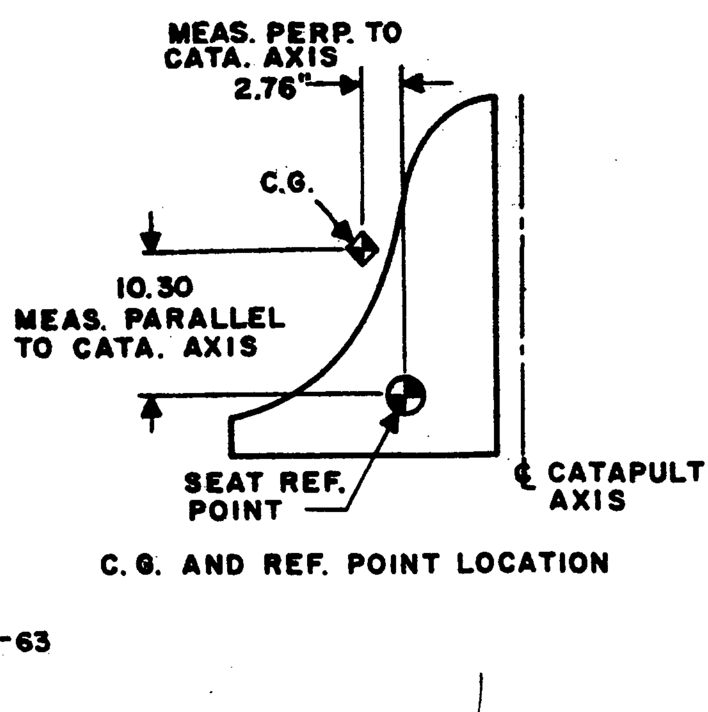
INSTRUMENTATION

4 Telemeter Channels; located on longitudinal tube of rocket carriage in same relative position as chest cavity of dummy.

1. Longitudinal 2. Vertical 3. Lateral 4. Angular

PHOTOGRAPHIC COVERAGE

3-16mm Eastman (15 ft. Tower)	1-16mm Super Speed (cart)
4-35mm Fastax (30 ft. Tower)	1-35mm Akley
1-Ribbon Frame (30 ft. Tower)	1-K-24
2-16mm Eastman (Aero Med)	1-35mm Eyemo
1-16mm Eastman (Armament Br.)	



C.G. AND REF. POINT LOCATION

TEST NO. 7

AMBIENT TEMPERATURE: 107.5°F WIND: 5 MPH W

ROCKET CARRIAGE

ɔ Med aluminum
r; oxygen mask.

Start:	Station 60.50	1st Aerojet Tripper:	Station 36.00
Tripper:	48.70	2nd Aerojet Tripper:	" 15.00
Eject:	47.00		
Actual Eject:			

ROCKET PERFORMANCE

o. 281

The 2.2KS accelerators ignited and fired normally. The two 2.2KS Aerojets ignited prematurely (approximately 300 feet from initial fire point). The rocket carriage stopped at approximately Station 03.00. It is believed that the premature retard rocket ignition was caused by the effect of a pressure wave building up in front of the rocket carriage, which in effect sand blasted the front slippers and frayed the wires leading from the power supply to the micro switch, thus causing a short circuit and ignition of the rockets.

REMARKS

nented.

ıbe of rocket
y of dummy.
4. Angular

Premature retard rocket ignition with accompanying clouds of rocket smoke totally obscured the rocket carriage from view throughout the test area. Traces of the dummy are seen during ejection, and initial trajectory stages are not visible. To date the ejection velocity (24 July 1950) is not known. AMC data complete on this test.

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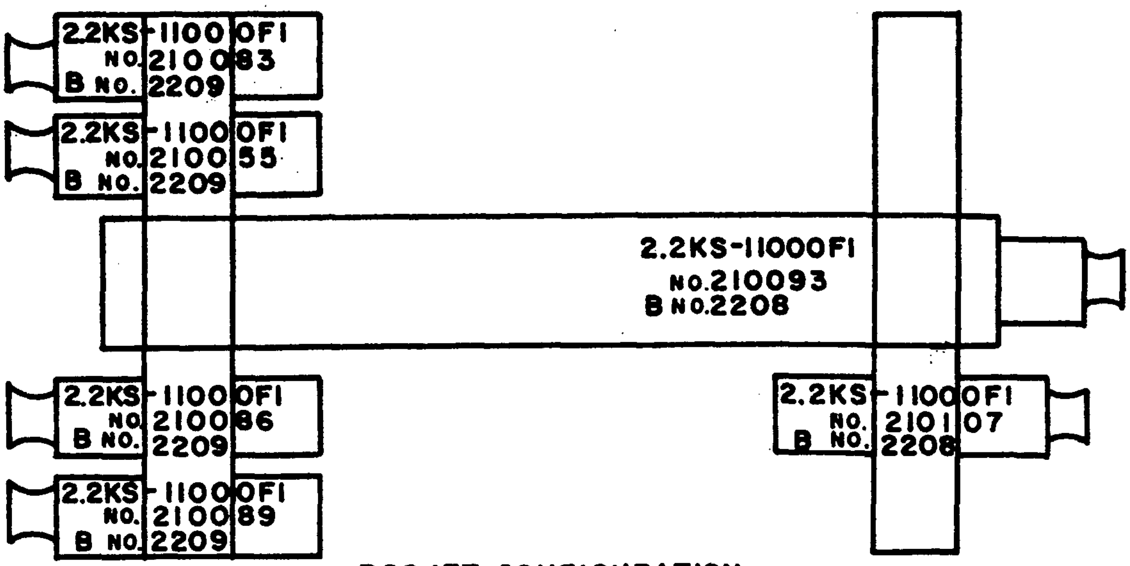

ROCKET CONFIGURATION

2

APPENDIX II

Calculation of Vertical Displacement of Seat C. G. for Test Nr 2

APPENDIX II

CALCULATION OF VERTICAL DISPLACEMENT OF SEAT C. G. FOR TEST NO. 2 (SEE AIR FORCE TECHNICAL REPORT NO. 6350, DATED MARCH 1951)

$$M = \frac{V}{(65.9)(\sqrt{T})}$$

WHERE,
M = MACH NUMBER
V (VELOCITY OF TEST CARRIAGE) = 578 mph OR 846 fps.
T (ABSOLUTE TEMPERATURE) = 301° K [5/9 (83 − 32) + 273]

$$M = \frac{846}{65.9\sqrt{301}} = .743\ (.768)$$

$$C_D = 1.25 + \Delta C_D$$

C_D = DRAG COEFFICIENT OF SEAT BASED ON AREA OF BACK OF SEAT, S.

$$\Delta C_D = 0.5\,M^4 = .174$$

$$C_D = 1.25 + .174 = 1.424$$

$$v_t = \sqrt{\frac{2w}{\rho\ C_D\ S}}$$

WHERE,
v_t = TERMINAL VELOCITY OF FALLING SEAT
W (WEIGHT OF EJECTION SEAT) = 324 LBS.
ρ (DENSITY) = 0.00222 SLUGS / CU. FT.
C_D = 1.424
S (AREA OF BACK OF SEAT) = 6.5 SQ. FT.

$$v_t = .177.7 \text{ fps}$$

$$y = \frac{Y\ v_t^{\ 2}}{k\ g}$$

WHERE,
y = VERTICAL DISTANCE BETWEEN SEAT AND COCKPIT
k (CONSTANT) = .8852
g (ACCELERATION OF GRAVITY) = 32.2 FT. / SEC.^{2}
$Y = K_1 \sin\alpha(\cot\alpha + K_1 + K_2)(\sqrt{2X} - K \sin\alpha) - (K_1 + K_2)X$

$$K_1 = \frac{V_0}{V}$$

V_0 (MAXIMUM EJECTION SEAT VELOCITY OF CATAPULT) = 58 fps

$$K_1 = \frac{58}{846} = 0.0683.$$

α (ANGLE OF PITCH OF SEAT) = 11°

$$K_2 = \left(\frac{v_t}{V}\right)^2 = 0.0437$$

$$X = \frac{k\, X_{FIN}}{V_t^{\,2}/g}$$

X_{FIN} (DISTANCE BETWEEN COCKPIT AND FIN) = 33 FT

$$X = .0297$$

$$Y = .0125$$

$$\Delta y = X_{FIN} \frac{C_L}{C_D}$$

C_L (LIFT COEFFICIENT) = −0.25

$$\Delta y = -5.80 \text{ FT}$$

$$y = \frac{Y\, v_t^2}{k\, g} = 13.85 \text{ FT}$$

HEIGHT OF TRAJECTORY AT FIN = 13.85 + 3.3 − 5.80 = 11.35 FT